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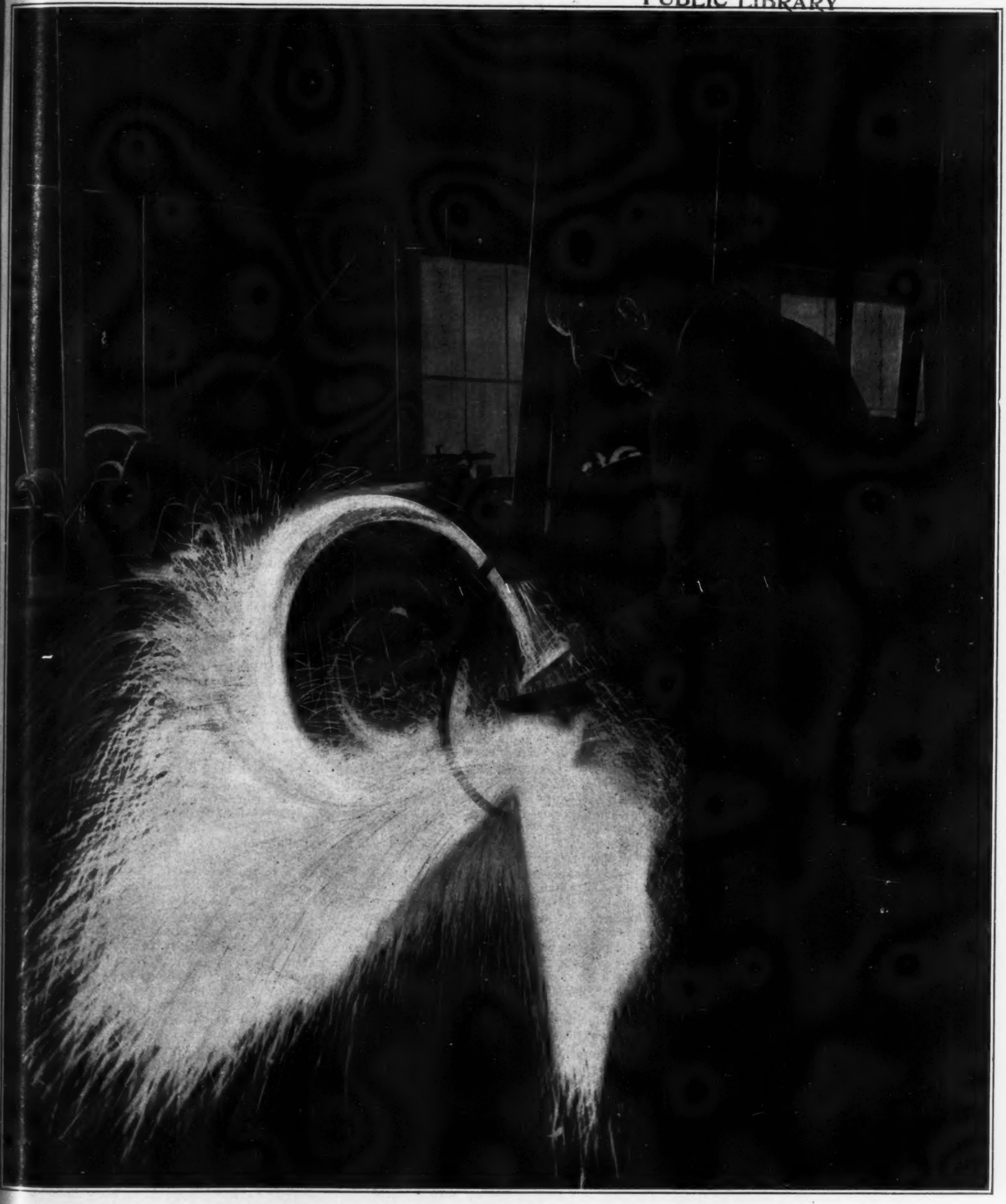


Spark Test Made Under Conditions that Enable the Camera to Vividly Portray Its Brilliancy.

GRINDING WHEEL SPARKS.—[See page 292.]

Calendars, Ancient and Modern*

Fitting Our Time Unit to Astronomical Constants

By Albert D. Watson

MEASUREMENTS of time based on the phenomena of nature were naturally regarded as peculiarly sacred by those ancients who worshipped the heavenly bodies. They venerated even the motions of the stars. This is not surprising to the open mind. Partial knowledge made them attentive to conspicuous rather than to less observed, though more significant, phenomena. It was natural that they should be impressed by sudden and brief, but overwhelming, exhibitions more than by changes that occupied long periods and made slow progress, requiring extended, systematic observation.

The calendars of the ancient world were based on the diurnal revolution of the earth; on the phenomena of sunrise, noonday and sunset, the periodic phases of the moon, its division into four quarters; on the four seasons with their wonderful variations of temperature and storms, thunder and dew, seed-time and harvest, and on all the multitudinous phenomena of the skies.

If we should suppose, however, that the primitive races were without knowledge as the result of observation, or devoid of interest in science, we should be in error. They may have been quite as scientific in spirit as ourselves, though they had fewer instruments for scientific pursuit. They were not equipped as we are. The solar year was not accurately determined till the 16th Christian century, and the ancients did not even know that the earth had a motion around the sun, yet the Egyptians of 4,000 years ago had fixed the year as a period of 365 days, divided so accurately and wisely that it was copied by the French Commune a little over a century ago as being the perfection of year divisions; and the Chaldeans had a year of twelve months two thousand years before that.

The day was the simplest of all calendar periods. Some of the most civilized nations of antiquity had no hours, but only such divisions as were understood by the terms "dawn," "forenoon," "afternoon," "twilight," "evening," and the four watches of the night. The ancient Greeks divided the day and the night each into twelve equal parts, and, as the parts were variable in duration, according to the season of the year, they were called temporary hours, summer hours, winter hours, etc. The Jews had hour divisions for the day, but many of the ancients had none.

The origin of the week is obscure. We cannot find any account of its beginning. It was probably, at the first, regarded as a quarter of the moon, and there is little doubt that this was its origin. The moon was a conspicuous object. Its motions were regarded as sacred. Its phases were observed by everybody. Naturally, one way of describing them was by stating what fraction of the disk was illuminated on any particular night. They did not understand the progressive increase and decrease of the moon's bright face, and had not, like the moderns, lost their interest in lunar phenomena.

Many of the ancients had no week in their calendar. The Greeks, for instance, had none, nor the Romans till after the reign of Theodosius. In fact, our own forefathers borrowed the week from the Orientals, and gave its days the names of their own deities. The people of the East numbered the days of the week. The Romans, who had no week, numbered the days of the month backwards from the calends, the nones, and the ides.

The beginning of the day has varied with different peoples. The Chaldeans reckoned their day from sunrise, the Jews from sunset, the Egyptians and Greeks from midnight, and we follow the example of the Greeks in this matter. The beginning of the week has also varied. The Egyptian week began with Saturday, the Hebrew week with Sunday. Are we sure that the Jews in changing the beginning of the day and the beginning of the week did not also change the identity of some of the days? Is our first day of the week in this 20th century the same day as was accounted the first of the week by Hammurabi, king of ancient Babylon, or by Moses when he kept the flocks of Jethro on the pastures of Horeb? Is it the same as the first day of the Egyptian week known to Rameses II. in Heliopolis and Thebes?

Romulus established a year of ten months, following, it is said, the ancient Alban year. Each of these months was of the duration of a moon's age, so that, if we omit the added days, which were outside the ten months, the year of Romulus would be less than 300 days in length. Did these added days have names when the other days of the year had none? It is not likely. The Romans had no week and no week-days. There could be no names for days if there were no months in these added days of the early Roman calendar. This seems to be an interesting field for investigation. It is well known that the Chaldeans (Accadians) had the week in their system 3800 years B.C., that the Egyptians had it 2000 B.C., that the Hebrews had it 1300 B.C., yet the Romans had no week whose days correspond with the days of the modern Jewish week. How did it come about that our first day of the week is the same as that of the Jews? The strong probability is that the Jews got their week from the Babylonians or the Egyptians, and, no doubt, we got it in turn from them. The only doubt arises in the question as to whether the Hebrews would not purposely change the days of their hated captors and oppressors, as they changed the first day of the week from Saturday to Sunday, and the beginning of the day from midnight to sunset.

The year has been a more difficult problem than any of the periods heretofore named. This is because of its natural division into a fractional number of days and moon-revolutions. The celestial wheels have no cogs. The earth travels a little too slowly for the convenience of the makers of calendars. If it completed its solar revolution in 364 days instead of in a little over 365 days—apparently an easy task—we should have a year consisting of exactly 52 seven-day weeks, and New Year's Day would no longer be a vagrant through the week, as it is at present.

The ancients might have preferred to divide a year of 364 days into 91 four-day weeks. In that case, the time-table would have been written in part: 24 hours, 1 day; 4 days, 1 week; 7 weeks, 1 month; 13 months, 1 year. Or they might have preferred 28 thirteen-day weeks, with a mid-week holiday. Then the table would have proceeded as follows: 24 hours, 1 day; 13 days, 1 week; 4 weeks, 1 month; 7 months, 1 year. Even this would not have exhausted the measures of so convenient a year. Knowing the period of the earth's solar revolution as exactly as we do, if we were making the calendar *de novo*, we should, no doubt, retain our seven-day week and establish a 28-day month, leaving the extra day of the common year with the leap-year day outside the week altogether, somewhat like the five extra-month days of the ancient Egyptians, or the sixty similar days of the early Romans. In such a year, Sunday would fall on the 1st, 8th, 15th, and 22nd of each month, and all other week-days in corresponding rotation.

The simple recurrence of days and dates in perpetual uniform relation makes such a calendar very desirable. Even the moon would then vary more regularly in relation to the month than now, but the whole year would be constructed on a solar basis. It would not matter when the extra days were intercalated. They might be made New Year's Day and leap-year day, the first and last days of the year, and have a festival character, giving the leap-year day a highly religious significance.

Such a calendar was proposed in a paper which appears in the Transactions of the Toronto Astronomical and Physical Society for the year 1896. The suggestion, then made for the first time, has been proposed since in a modified form; but nothing can be done till some family of nations acts co-ordinately, realizing that all institutions, however sacred, were made for man, and not for the honor of the ancient heathen deities. The gods have hitherto had the power to protect their calendars, but their power consisted in the partial knowledge and prejudice of the people.

The vital principle of any scientific calendar is the intercalated day which is a part of the year, but no part of the week. The need for such a division of the solar year appears when it is realized that at present we use fourteen different calendars, two for every day in the week, one of the two being for the common, and the other for the leap year.

Reform of the calendar is not excluded by the nature of astronomic law or motions, but by the inertia of conservatism, *vis a tergo* which drives us on in the old courses, the skeleton hand of the past, which holds us back when we would change or improve. There will, doubtless, some day be a thoroughly scientific calendar in use throughout the world. It is to be hoped that our own great empire that has laid the world under tribute so often in scientific enterprise will do so again. Meanwhile, we rest in the assurance that whoever *gets* the credit for devising a scientific calendar, we, of the Royal Astronomical Society of Toronto, shall *deserve* it.

All historical beginnings are nebulous. The beginnings of the calendar are no exception to the rule. Sometimes the nebulæ out of which worlds appear are so distant and obscure that we cannot see them at all. It is the same with the beginnings of the almanac. Astrological works, copied from their ancient originals for the library of Assurbanipal, have been ascribed by recent scholars to the reign of Sargon of Accad (B.C. 3800). In these documents the dates used show a year of twelve lunar months, a thirteenth being intercalated four times in eleven years. The order of the months is everywhere the same, and the first of the year is Bar zig-gar, which corresponds with the Assyrian Nisan and with our March-April period.

The Manda, probably the progenitors of the Medes, lived in the days of Sargon of Accad, and invented a four-letter monogram containing the initials of the four signs of the Zodiac which, at that date, marked the four seasons. This monogram was used thousands of years afterward by the Shemitic Assyrians. They recognized the sway of the sun, and laid much stress upon the seasonal changes.

All Babylonian documents from the time of Hammurabi (B. C. 2200) show a fixed calendric system, and a year beginning with Nisan. It has been suggested that, as the Spring Equinox corresponded, prior to Sargon's time, with a different Zodiacal sign, it is possible that Nisan was the first month of winter when the calendar was made, and that season, and not the spring, may have then been regarded as the first of the year, as it is with us. Of this we can find no conclusive evidence. Much documentary testimony exists showing that the Greeks of an early date knew that the Equinoxes move along the Zodiacal belt.

There is little doubt that most of the early people established the year on a sidereal plan, thinking that such a system would also correspond with the seasons. The makers of the calendar, not knowing that the seasons change their relation to the stars as the centuries pass, supposed that in making the year begin with Nisan, they were binding that month permanently to the particular Equinox or Solstice then corresponding to it.

The Accadian months are lunar, yet their names show also a sidereal relation. Bar zig-gar, the Nisan of Accad, and our March-April month, signified "the sacrifice of righteousness" and the corresponding Zodiacal sign was the ram, an animal much used in sacrifice. The Egyptians also introduced their sacred year with the Spring Equinox and the Aries sign. They, too, venerated the ram. The great temple of Amen-Ra, at Thebes, was approached through an avenue of ram-headed sphinxes. Did they find their sphinxes in the skies, or was the Egyptian ram transferred to the Zodiac? To a modern observer, the latter proposition is the more likely. Kharsidi was the second Accadian month. The word means "the propitious bull." Taurus is its sign. Kas was their third month, and the name means "twins." Gemini is its sign. It is, therefore, very clear that these months were named with reference to the stars. The Egyptians had both a civil and a sacred calendar. Their civil year was solar, and their sacred year sidereal. The former consisted of twelve months of thirty days each, with five days added at their close, to bring the days up to 365. The French Commune adopted this system nearly 4000 years later as the best the world knew, even then. Not knowing the period of the earth's solar revolution, nor even the fact that it made such a journey, the Egyptians took no account of the hours, minutes, and seconds, which, as we know, completed the period.

The Nile dwellers fixed their great feast, the Festival of the Valley, on the 29th day of the second month of the inundation. This gave it a seasonal or solar relation. Their civil year began with Thoth in the autumn, and the Hebrews adopted the same season for the beginning of theirs. The Egyptian sacred year was sidereal, and Aries marked its beginning. In this also they were followed by the Israelites.

When the Hebrews left Egypt and instituted the Passover, they were commanded to regard the month Abib, then just begun, as the "beginning of months;" that is, as the first month of the year. This month was Nisan, and was so called after the Babylonian captivity, though most of the other Hebrew months received Syrian names.

The Jewish year has always been, like that of the Babylonians, one of twelve lunar months and one intercalary month added, when necessary, to keep the year in proper relation with the seasons. At first the embolismic year was added once in about every three years. In later times, seven months were introduced in the course of every nineteen years.

There is evidence of the luni-solar nature of the Hebrew calendar in their earliest literature. "And God

* From the May-June issue of the Journal of the Royal Astronomical Society of Canada.

said, let there be lights in the firmament of heaven to divide the day from the night, and let them be for signs and for seasons, and for days and years. . . . And God made two great lights; the greater light to rule the day, and the lesser light to rule the night. He made the stars also."

Where new moons were sacred, it became a matter of much importance to note the time of their appearance. A dweller in ancient Israel learned the time from signal fires upon the hills, or from runners who carried the news out from the large cities over the surrounding country. If there was any doubt of the day on which the thin crescent of the new moon appeared, it was necessary to keep two days, that the right one should be observed at all hazards.

A new moon was never to be observed on a Sunday, a Wednesday, or a Friday. If a dweller in Zebulon, for instance, went out at night and saw the signal-fire burning on Tabor's summit, he immediately proceeded to keep the feast of the new moon. If, however, the day was the first, the third, or the fifth, he kept the following day. If a runner came to his house, and told him that the silver crescent had been seen after noon and before sunset, the following day, which began at sunset, was the "new-moon" day, unless it was one of those on which a new moon was not to be observed, in which case the day following it was kept.

The embolismic month of the Jewish year is intercalated before the month Adhar, the last month of the sacred year, the month immediately before Nisan. The Jewish common year had three forms.

1. The ordinary or regular common year of 354 days.

2. The imperfect or defective common year in which the third month, Kislev, had only 29 instead of 30 days, and the year had 353 days.

3. The perfect or abundant common year of 355 days, in which the second month, Marheshwan, had 30 instead of the usual 29 days. Similarly, there were three embolismic years corresponding to these, and consisting of 384, 383, and 385 days, respectively.

The Jewish calendar, like all religious institutions with features peculiar to themselves, is assured of perpetuity as long as the religious system endures which gave it its origin. When all separating walls are broken down, when the races and their institutions are all thrown into the melting-pot, and the pure gold of humanity issues refined and unified into one homogeneous expression of life and its highest uses, who can tell whether there will be more of the Jewish or of the Gentile institutions in the new regime?

The ancient Arabian calendar was purely lunar. Its year consisted of 12 lunar months, with no intercalation to keep them in constant seasonal relation. Their year retrogressed through the four seasons in about 32½ years. Arabian or Mohammedan years are arranged in cycles of thirty, nineteen of which are common years of 354 days each, and eleven are intercalary years with an additional day appended to the last month. This brings the average duration of the Mohammedan month to within 2.8 seconds of an astronomical mean lunation, an error which would amount to a day in about 2,400 years.

The pilgrimage to the Kaaba took place in early times in the last month of the year. Necessarily, this pilgrimage would take place 11 days earlier at every recurrence. When it fell so early as to come before the harvest, the pilgrims had difficulty in getting enough food for their journey. The date of the pilgrimage could not be changed, being too sacred. The calendar was, therefore, modified by a process which made the year luni-solar, and brought the pilgrimage always in the autumn.

Four of the Mohammedan months were sacred. They were the first, second, seventh, and twelfth. Three of the sacred months being consecutive, the fiery-hearted Arabs could do no fighting for the whole period of three months, till Mohammed came to the rescue and interpreted this restriction as meaning that they could only fight with Mussulmans in these months. He then led an expedition against the heathen himself, and the situation was no longer intolerable.

China, like nearly all the Eastern nations, has a lunar calendar. The months are alternately 29 and 30 days in duration, and begin when the moon is between the sun and the earth. The year begins and ends when these three bodies are in the same relation. The Chinese add a thirteenth month to the year after every thirty lunations. Such a plan does not keep the year in consonance with the seasons, therefore instructions have to be issued relating to planting, reaping, fishing, and hunting. This accounts for the great bulk of the Chinese almanac, which is said to have the largest circulation of any book in the world.

The almanac for the year which closed February 9th, 1910, shows that year to have had 13 months; a first month, a second month, an intercalary second month, then a third, fourth, fifth, etc., to the last, which is considered as a twelfth, but is in reality a thirteenth month. As the intercalary second month of that year contained only 29 days, the whole year contained 383 days. The common twelve-month year contains necessarily 354 days.

In ancient times, the Chinese years were named after certain animals. Even the hours were so named. A Chinaman will sometimes even yet tell you he was born in the dragon year or in the dog year. Clocks are still running which strike the hour of the rat or the horse. Expressions such as "before horse," or "after horse," meaning before or after noon, were in use. Noon was "full horse" in the old days.

The Chinese have devised a most ingenious clock, which is so explicit that the observer may see, for instance, on its dial that he is looking at a Chinese clock in the first hour of the first day of the first month, which consists of 29 days, of the 48th year of the 76th cycle of 60 years, which is also the 2462nd year of Confucius, the third year of the Emperor Hsaun Tung, the 4548th year by the sexagenary system, the 4608th from the time when Hwang Ti ascended the throne, and which corresponds most nearly with our year 1911.

The Chinese hour has 120 minutes, the noon hour being the period between 11 A. M. and 1 P. M. of our time. This is the horse hour of the ancient calendar. The time from 11 P. M. to 1 A. M. is the rat hour. Half of these hours was A. M., and the other half was P. M.

A notable contribution to the calendar was made when the Athenian astronomer, Meton, observed that 235 lunations correspond in duration almost to an hour with the period of 19 solar years. In fact, there is only 1.5 hours of difference between 235 lunations and 19 Julian years. It may help us to understand how some of the ancients arrived so near to final truth respecting heavenly motions, if we remember that, long before the time of Meton, some Babylonian sage had discovered the *Saros*, a cycle consisting of 6,585 days and 8 hours, during which period there are 223 lunations. The period consists of 18 Julian years, 10 days, and 18 hours. At the end of this period all eclipses are repeated nearly as before. The computation of eclipses and all recurrent luni-solar phenomena was much simplified by the discovery of this cycle.

The practice of intercalation is common to all calendars and is necessary in order to make the year solar and seasonal. The Aryans have always been more disposed to favor the solar, the Semites the lunar, division of time. The moon loses sway over intelligent people, while the uninstructed still tend to regulate their times and seasons under the guidance of the lunar phases. The Hebrews are immensely clever, but the progress of a race is sometimes inhibited by its traditionalism.

A few words as to our own calendar. Our day names were derived from the Scandinavians. The week came to us from the Jews, the month and the year from the Romans. No institution was ever more subject to whim and caprice than the Roman calendar. The ten months of Romulus became twelve under Numa, who added January and February. The year was now one of 354 days, having 12 months of 29 and 30 days alternately. Then a day was added to make the number odd because odd numbers were accounted more propitious. A month of 22 and 23 days alternately was intercalated between the 23rd and 24th of February in every second year. The average number of days in the year was now 366½. Later the intercalary month was omitted in every 24th year. This transaction made the year average almost solar.

After this, the priests seem to have had power to increase or diminish the days of any year at will under any plausible pretext. Their plan was to postpone an event or hasten it without changing its date. They intercalated days at will. No one knew just when a year would begin or end. This continued till Julius Cæsar found the year A.U.C. 707 so disordered that it was necessary to add two months, though it was already a year of thirteen months. He thus made it a year of fifteen months, being 455 days.

The average year was now fixed at 365¼ days by giving the odd months 31 days, and the even ones 30 days. The exceptions to this rule were the common years when February had only 29 days. Even now the priests seemed not to have enough intelligence to carry out Cæsar's orders, and their mistakes had to be corrected in the next reign. But Augustus, wishing to be accounted a patron of science, imitated Julius Cæsar by having August named in his honor, as July had been named after his predecessor. But August had only 30 days, and July had 31. Why should the month of Augustus be briefer than the month of Julius? This was an indignity not to be suffered, so another day was taken from the already long-suffering February and added to August. Then, that there should not be three 31-day months in one quarter, one day of September was pushed on into October, and the 31st day of November was pushed on into December, and, lo! we had our calendar. It has always been called the Julian calendar, but if the great Cæsar had known what anomalies his successor had introduced, he would have disowned it, and the least the world should have done was to have restored the Julian calendar to the state in which Julius Cæsar intended it to remain. This should be done now, and without the least delay. The Julian calendar is clumsy enough with all the improvements of the Gregorian reforms, without the silly meddlings which have made it a curio for all time.

The Gregorian amendments to the calendar are described in a thousand books, almanacs, and cyclopædias, and though a worthy and helpful reform, need not be explained here. Just this observation, however, may be made. We speak of the Julian and Gregorian calendars. Cæsar and Gregory were the instruments by which these were adopted, and are to be commended. Perhaps it is well to remember, however, that the astronomer Sosigenes was the author of the Julian calendar, and that the Italian physician, Aloysius Lilius, devised the Gregorian reform, but died before its introduction.

The Cost of Success

The time-worn aphorism of the candle lighted at both ends lasting only half its natural span, has never applied more accurately or more intensely to the average American city man than it does to-day. The higher cost of living, the desire for social recognition, and the luring attractions of the city are all contributing causes of an inexorable desire for success, that, hydra-headed though it may be in the multiplicity of its forms, still means, when reduced to its ultimate factor, only a firmer grip on the elusive god Mammon.

The indomitable driving force of American enterprise has, it is true, made itself felt in all parts of the civilized world. That fact in itself has, consciously or unconsciously to us, plastered an immense amount of comfort on our collective vanity. For American success does stand out unique and gigantic when viewed *in toto*, and without further analysis. But sooner or later we shall see that we are paying the price with a vengeance and that the law of compensation is asserting itself, surreptitiously but none the less surely. Thoughtful men are daily becoming more and more aware of the fact that the hundreds of thousands of Americans, we might say the millions, who make possible the abstract fact of our success, are individually traveling at a terrific pace to give us this so called supremacy. The intensity of their efforts may wear them out, but new recruits are ever ready to fill up the gap and keep the mighty ball rolling.

When we are constantly geared up to a high speed, physiological laws raise a warning that read aright means, "Thus far shalt thou go and no farther." The very pleasures and recreations of the city man are unphysiological and exaggerated. Late hours with loss of sleep, dining at a time when repose is indicated, and violations of hygienic and dietetic laws in the matter of proper exercise and regular nourishment are all diminishing a vitality that can only be fleeting under such abnormal stress and strain.

Of what value is success if we spend ourselves untimely in its attainment? It is not hard to see that the unnatural demands of business and pleasure in our life are causing an ever increasing drain on the physical resources of the city individual. The mad scramble for success with its accompanying ability to indulge in dubious pleasures, would be ludicrous were it not tragic.

It is a terrible fact that cardiac diseases, cancer, and arteriosclerosis are eating more and more into the vitals of a nation that should be robust and virile. Insanity has increased enormously in the last half century. Sudden deaths are so common-place that they pass unnoticed. And if we were to dwell upon the subject in detail, it could be shown that the intensity and single purposeness of the average American in the gratification of his lust for success, as well as for the enjoyment of exaggerated pleasures, play no small part in the increase of disease, insanity, and shortened lives.

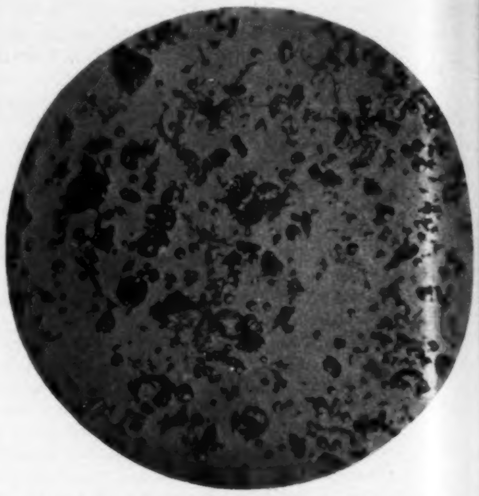
Preventive medicine has, it is true, diminished the mortality of infectious diseases; it has mostly done away with the dangers of scourges and plagues; it is making such rapid progress that miraculous discoveries soon appear commonplace in the light of new discoveries. But preventive medicine has a still greater sociological mission to perform. It must teach the lesson that a normal life, in which sufficient leisure and repose alternate with bustle and hard work, is far more to be desired than riches and exaggerated pleasures which are abnormal. Such a knowledge of how to live normally, once attained and wisely followed, would go the longest possible way in diminishing the labors of medicine.—*The New York Medical Journal.*

Grinding Wheel Sparks*

How They Indicate the Character of Steel

By R. G. Williams†

Microphotograph of Chips Made by Wheel Cutting Properly.



Microphotograph of Particles Showing Effect of Heat.

When certain kinds of metal, namely, iron and steels, are pressed against a rapidly revolving grinding wheel, sparks are produced. Sparks are pieces of metal which are torn away from the mass being ground, and during this tearing process are heated to such a high temperature that they become molten. In this highly heated condition they give out light, the amount of light produced being proportional to the temperature to which the metal is heated.

It is one of the natural laws of physics that when a liquid drops, or is thrown through the air, it takes a spherical form. Ordinary rain drops are an illustration of this fact. Consequently, we would expect the solidified sparks to be in the form of little solid globules. In a general way this is true, but not exactly. When these sparks first cool they do take on the form of globules, but as they get colder, the outside and solid shell contracts on the liquid interior until a point is reached where the pressure of the liquid interior is great enough to rupture the outside shell, and the phenomena, which we refer to as spurting or forking, then takes place. All that is left is part of a hollow spherical shell.

As far back as 1804, a Frenchman made some spark experiments with an old-fashioned grindstone, but it was probably not until the introduction of high speed steel that grinding wheel sparks became of interest to the ordinary shop-man. It was noticed that high speed steel did not spurt in the same manner as ordinary carbon steel, and this led to the question of what it was that produced different kinds of sparks. It is common knowledge that the air contains oxygen, and it is the combination at high temperatures of oxygen in the air and the constituents of the metal being ground that produces spark characteristics peculiar to different metals. Carbon is the most influential constituent, the volume and brightness of sparks being roughly proportional to the amount of carbon present in the steel. In other words, a high carbon steel gives a large volume of sparks; a medium carbon steel gives a moderate volume; and a very low carbon steel, or wrought iron, gives a still smaller volume. High speed, or self-hardening steel, as it is sometimes called, is in a class by itself, and the characteristics peculiar to this class of steels will be taken up later in this article.

Chips is the name used for these sparks when they have become solidified, and by an examination of these chips through a magnifying glass it is possible to tell whether or not the wheel was cutting properly. A good many kinds of material, notably high carbon steel tools, require a very cool cutting wheel; that is, one which will generate very little heat during the grinding operation. This is necessary, for, if the wheel generated considerable heat, there would be great danger of drawing the temper of the tool and its usefulness being destroyed. If upon examining chips through a magnifying glass, we see a predominance of curls over globules, we say that the wheel is cutting properly and generating a very small amount of heat, but if the sample of chips shows a predominance of globules over curls, we then know that the wheel is generating more heat than it should.

Whether or not a wheel is cutting properly can also be judged by the volume of sparks produced during the grinding operation. If two wheels are working on the same kind of steel, and one wheel is only producing a small volume of sparks, while the other wheel is producing a large volume, it is an indication that the first wheel is not cutting satisfactorily. The most common cause of a wheel not cutting satisfactorily is being in a state which those initiated into grinding wheel language know as glazed. When the minute cutting particles of a wheel, which should stick out far enough to penetrate the material being held against the wheel, have worn down flat, have lost their sharpness, and no longer penetrate as they should, the wheel is then in a glazed condition.

It has been shown that sparks will be produced from a cylindrical piece of work when the depth of cut is only five-millionths of an inch. This will give you a good idea of why the volume of sparks is a correct indication of how the wheel is cutting. For instance, if owing to improper supply of cooling liquid, or for some other reason, a shaft being ground is expanding just a little more on one side than the other, which would cause the shaft to be out of round when finished, the volume of sparks produced will be greater from the side which is expanding than from the other side.

The cut shown is a reproduction of a chart used in Purdue University by John F. Keller, instructor in forging, to bring to the pupils' attention the spark characteristics of different iron and steels, as a means of roughly determining what kind of iron or steel they are working with. While not strictly accurate, in that the sparks shown are free-hand drawings, nevertheless, it is both interesting and instructive.

Fig. 1 gives an idea of the characteristics of sparks from wrought iron. Wrought iron is free from carbon and the sparks follow straight lines which become broader and more luminous until they reach their maximum size, then gradually diminish until they grow dark. Wrought iron is easily distinguished from iron which contains carbon, that is, steel, in that there are practically no sparks which spurt or fork. The sparks from wrought iron present an analogy to meteors, or shooting stars. Meteors are masses of iron practically free from carbon which have been traveling about in space and come in contact with the air which surrounds the earth. They are traveling at an enormous rate of speed and sufficient friction is set up between the meteor and the air to heat the meteor to a temperature where the iron it contains combines with the oxygen in the air. In other words, the iron burns and this burning produces light.

Fig. 2 shows the sparks from mild steel. This contains a low percentage of carbon which is evidenced by the appearance of a few sparks which spurt, otherwise the sparks are similar to those from wrought iron.

Fig. 3 represents the sparks from tool steel, and it will be noticed that the number of sparks which spurt are greater than from mild steel. Also, the number of sparks characteristic of wrought iron have diminished. The color of the sparks has also changed from a light straw to nearly white.

Fig. 4 gives an idea of the sparks from high carbon steel. The characteristic iron spark is no longer present and practically all the sparks spurt, a great many respurting a number of times. It will be noticed that the distance the sparks travel away from the grinding wheel has also diminished. In high carbon steels, the iron and carbon are in such form that they most readily combine with the oxygen in the air.

Fig. 5 represents high speed steel sparks. Although high speed steels contain a fairly high percentage of

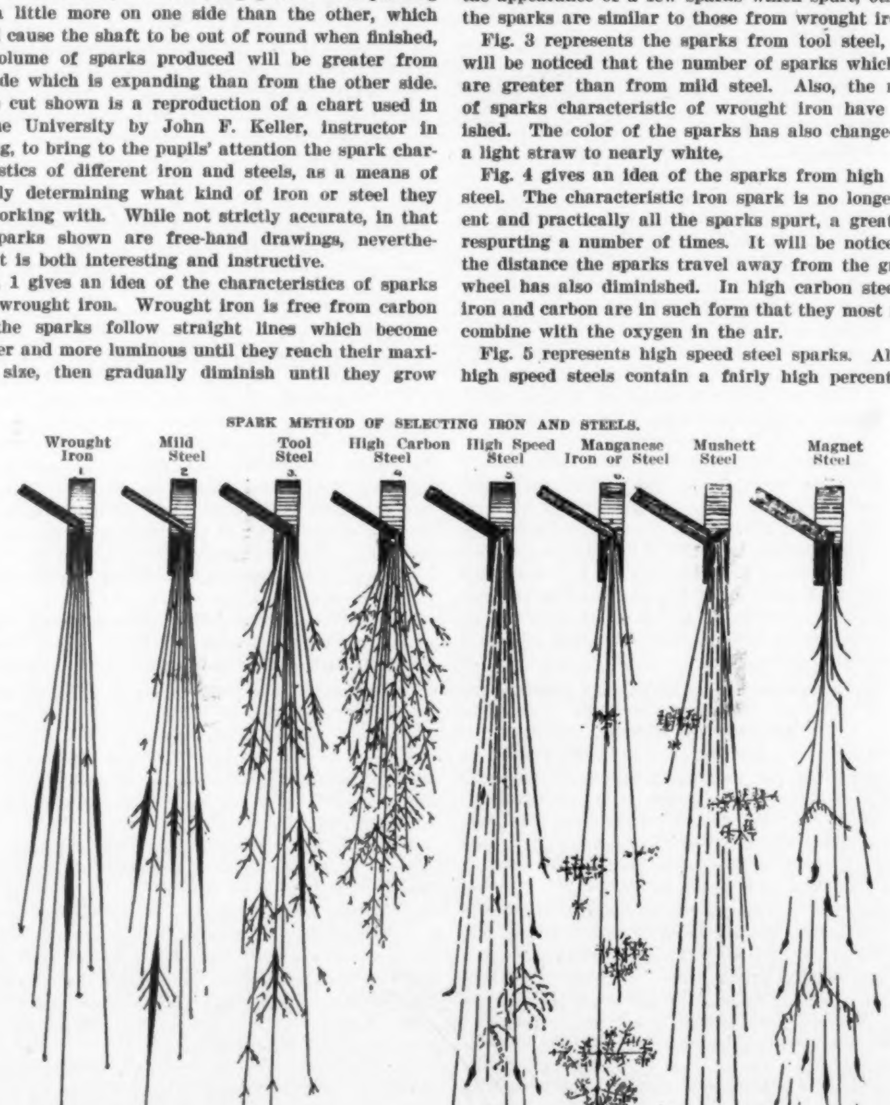


Chart Prepared by John F. Keller to Show Spark Characteristics.

* Reproduced from *Grits and Grinds*.

† The writer acknowledges his indebtedness to Mr. John F. Keller, instructor in forging and heat treatment of metals, Purdue University, for the inspiration that led to the selection of this subject, for the spark diagram shown herewith and for much of the text used in describing the diagram.

carbon, the chromium and tungsten they usually contain has the function of holding the carbon in such a state that the sparks characteristic of ordinary tool steel are entirely absent.

The sparks follow a straight line similar to wrought iron sparks, but give very much less light and end abruptly in a chrome yellow, pear-shaped mass.

Fig. 6 shows the sparks produced by a certain kind of manganese steel which contains very much less manganese than is present in the common manganese steel used in railroad frogs and switches. A characteristic of sparks from manganese steel is their intense brilliancy and white color.

Fig. 7 shows the kind of sparks from the earlier grade of Mushett air hardening steel. These sparks are hardly luminous, being dark red in color, and although this steel contains about 2 per cent of carbon, it shows none of the characteristic sparks obtained from a straight carbon steel containing the same amount of carbon.

Fig. 8 represents sparks from a special brand of steel known as magnet steel. The color of these sparks is orange, the characteristics differing in the manner shown by the diagram.

These are not all the varieties of sparks capable of being produced from iron and steels, but should give the reader an idea of the most common varieties. The soft metals like brass, bronze and aluminium do not give sparks, while cast iron gives a very short, dark red spark which ends in the production of a spurt in all directions.

Practical use can be made of the spark test in a good many instances, notably by the tool maker who has to handle different kinds of steel. Should a carbon steel be given the heat treatment required by a high speed steel, it would be ruined; or should a high speed steel be given the heat treatment proper for an ordinary carbon steel, it would not work at the highest efficiency. By using as standards steels of known properties, one about which there is the slightest degree of doubt can be readily correlated by means of a spark test.

The Reconstruction of the Quebec Bridge*

A Design Proposed by a Russian Engineer

By Prof. G. Kriwoschein, Colonel in the Imperial Russian Engineer Corps, St. Petersburg

It will be remembered that the Quebec bridge over the St. Lawrence River in Canada collapsed, while in process of construction, on the 29th of August, 1907. The commission appointed by the government ascertained that the immediate cause of the collapse was to be found in a faultily constructed member of the lower chord; from a careful consideration of the description of the bridge as well as of the collapse itself, however, it is clear that the real reason lay in faulty design, in particular:

(1) The extreme narrowness of the bridge, which was only 1/27 of the mean or average span, and 1/4.7 of the height of the principal truss.

(2) The great length of the cantilever arm, in comparison with the span of the side opening (1/1.12) and, as a necessary consequence of the physical proportions just named, the deficient lateral rigidity when subjected to wind, as well as the extremely small resistance of the bridge to torsional stresses (in consequence of the excessive loading of one truss).

After the collapse of the bridge, a commission known as the Board of Engineers was appointed by the Canadian government; this body worked out a new project for the bridge, which showed the same fundamental errors. This commission was occupied for three years with the preparation of the design, which involved the expenditure of $150,000. The result was a project which was in every sense inadequate.[1]

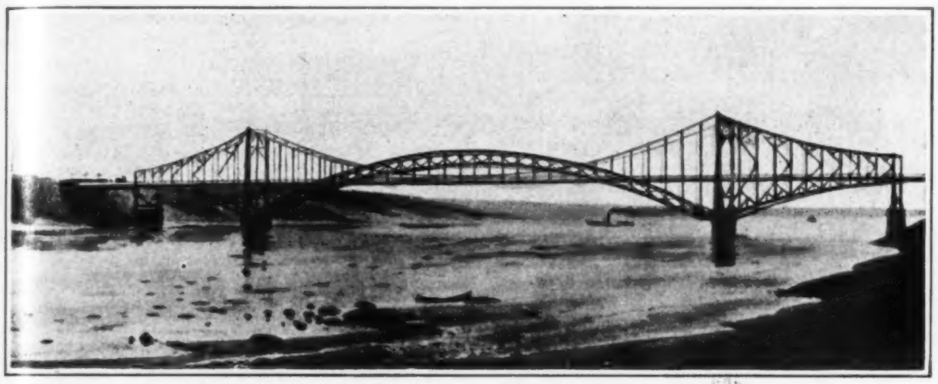


Fig. 1.—The Design Proposed for the Quebec Bridge by Prof. Kriwoschein.

Then a new competition was advertised by the commission on January 3rd, 1910, for the submission of designs and methods of carrying out the construction, in which one of the conditions was that the projects should be submitted absolutely free of charge. In the endeavor to apprise the commission of one of the possible solutions of the extremely difficult problem, the author worked out a sketch design of the Quebec bridge (Fig. 1) and submitted it to the commission for its opinion. In the case of the system proposed by the author, there was a saving in cable alone of $1,365,000, and a still greater saving in the bridge arch.

This circumstance should have induced the commission to examine and work out in detail the solution thus submitted. Instead of this, however, on account of the fact that the project had originated abroad, this body did not think fit to submit the project to a closer inspection, in spite of the correctness of the technical proposal, in complete indifference to the fine appearance of the structure and to the resultant saving of expense, and contented itself with the statement that the difficulty of constructing the movable supports stood in the way of the system proposed.

Without permitting myself to enter into a critical

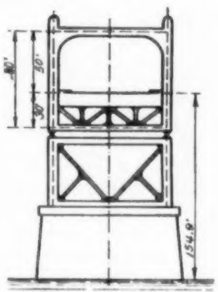


Fig. 5.—Cross-section at the End Abutment.

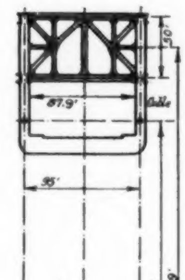


Fig. 6.—Cross-section at the Center.

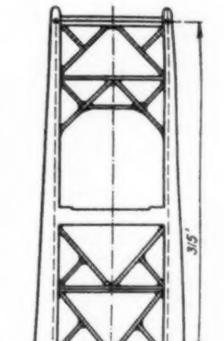


Fig. 7.—Cross-section at the Main Abutment.

* Translated from *Der Eisenbau*.

[1] Scientific American, No. 7, 1910, pages 148 and 154.

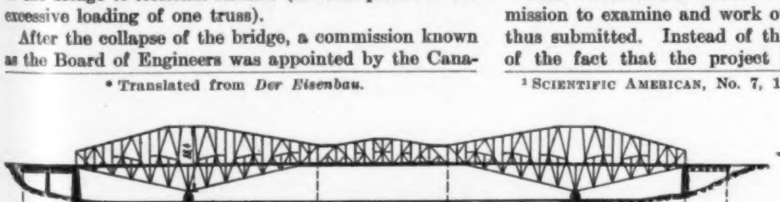


Fig. 2.—The Quebec Bridge as Approved by the Canadian Commission.

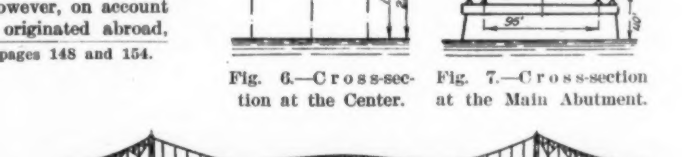


Fig. 3.—Design for Quebec Bridge by Prof. Kriwoschein.

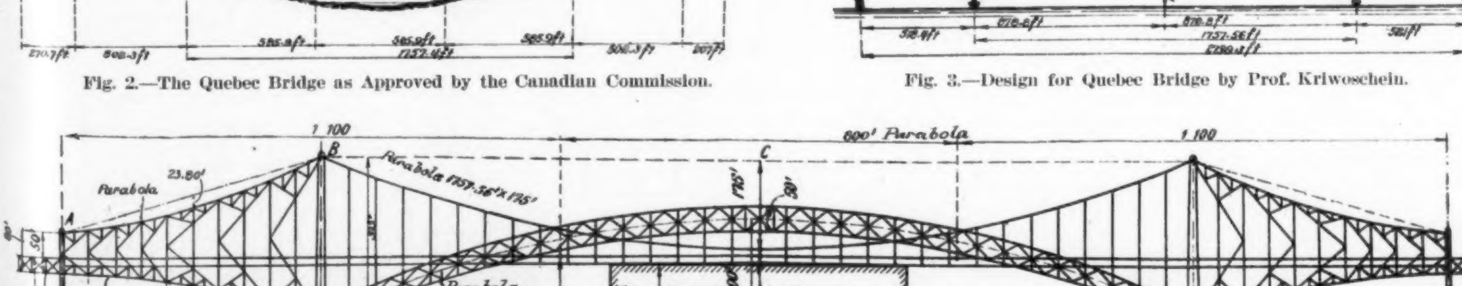


Fig. 4.—Details of Prof. Kriwoschein's Design.

consideration of the answer of the commission, I can only observe with satisfaction that the commission has now decided upon a considerably greater breadth of bridge, which seems to indicate that recognition is now gained for the fact that the extremely small breadth was one of the principal causes of the collapse.

Figs. 2 and 3 represent comparative drawings of the Quebec bridge of which:

Fig. 2 is after the design of the commission.

Fig. 3 is after the design of the author.

In Fig. 4 the elevation and the dimensions of the arch bridge design may be seen, in which horizontal measurements, the heights in the clear, the spans, etc., as well as the super-elevation of the railway were adopted in accordance with the specifications of the commission. The dimensions are as follows:

The side-spans 5,210 feet; the middle-span $L = 1{,}758$ feet; the height of the catenary $f_1 = 1/10\,L$; the height of the arch $f_2 = 1/9\,L$; the breadth of the bridge $b = 1/3.3\,h_0 = 1/18.5\,L$, in which h_0 is the height of the truss above the abutment. From these measurements it is clear that the stability of the bridge is thoroughly satisfactory.

The system of the principal truss of the bridge consists in the middle span of a combination of the suspension cable with the arch, in which the cable is hung from the side girders. The ends of the side girders are anchored to the shore.

Of the four supports, one must be fixed, or immovable; while the others are movable. The arch may be a three hinged arch, in which case the system is statically determinate; or it may be a two hinged arch, in which case the system is statically indeterminate. The stresses resulting from variations in temperature in the latter system are insignificant (not over 9 per cent).

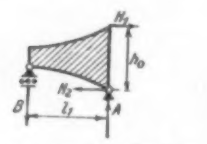


Fig. 12.—Side Girders

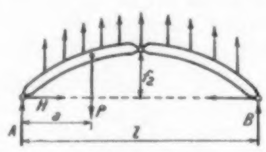


Fig. 13.—Middle Arch.

Figs. 5 to 7 represent cross-sections of the bridge. In Figs. 8 to 11 the method of erecting the bridge is clearly seen. First of all the side girders are set up. Then the cable is drawn across from one girder to the other, while the shore ends of the side girders are anchored by means of temporary anchor chains. Now the roadway and the bridge arch may be attached to the cables, during which process it is to be noted that the ends of the arch must not be fastened to the girders. After the entire middle arch is assembled, the union of the arch with the girders may be effected. In this way the entire weight of the bridge itself may be transmitted to the cables, without producing any stress in the arch, so that the latter is strained only by the live loads.

The conditions of equilibrium for the side girders, neglecting the cables and the arch, are represented by the following expressions (Fig. 12):

(1) $H_1 - H_2 = 0$.

(2) $A - B = 0$.

(3) $H_1 h_0 - BL_1 = 0$.

The results of the calculation are as follows:

(1) The horizontal shear $H_1 = H_2$ is equal to the tension in the catenary.

(2) In the girders we have only vertical compression.

$$A = B = \frac{H\,h_0}{L_1}$$

Let us now consider the middle arch (Fig. 13). The following forces will be acting on the arch: The load P, the tension in the suspension rods q, the horizontal shear H and the vertical resistances of the girders A and B.

From the moment equation with respect to the right joint

$$A\,L + \frac{qL^2}{2} - P\,(L - a) = 0,$$

we obtain

$$A = \frac{P(L-a)}{L} - H\,\frac{4f_1}{L},$$

in which has been substituted[2]

$$q = H\,\frac{8f_1}{L^2}$$

If we substitute in the moment equation for the middle joint for the forces situated to the left of this joint

$$A\,\frac{L}{2} + \frac{qL}{2}\cdot\frac{L}{4} - P\left(\frac{L}{2} - a\right) - Hf_2 = 0$$

the value for A which has been determined as above, we find that the horizontal stress in the chain and the horizontal thrust of the arch are equal:

$$H = \frac{Pa}{2(f_1 + f_2)}.$$

For the case of uniform loading of the central arch we obtain:

$$H = 2\int_0^{\frac{L}{2}} \frac{pada}{2(f_1+f_2)} \text{ or } H = \frac{pL^2}{8(f_1+f_2)}.$$

This formula is significant in that the horizontal stress of the cable and the horizontal thrust of the arch are not inversely proportional to the height of the catenary f_1, but rather to the sum of the heights of the catenary f_1 and of the arch f_2. Thus, for example, if $f_1 = f_2$, we have

$$H = \frac{pL_2}{16f_1},$$

that is to say, half as much as for the catenary with a stiffening girder.

Saving in Material.—The saving attained by the application of the system proposed by me, consisting of a cable with an arch in place of a cable with a girder, may be proved in the following way:

Since the weight of the Quebec bridge is not known, let us take the length of the Manhattan bridge (from *Engineering News*, 1909, No. 16. Manhattan bridge, Ralph Modjeski's Report); this is entirely permissible since the arches of both bridges are almost equal in size.

The live load $p = 16{,}000$ pounds per foot.

The permanent load $g_0 = 18{,}000$ pounds per foot without the cable.

The permanent load $g = 22{,}900$ pounds per foot with cable.

The central arch of the Manhattan bridge $L_1 = 1{,}470$ feet.

The central arch of the Quebec bridge $L_2 = 1{,}758$ feet.

If we assume that the weight increases in proportion to the span of the arch, in which case the coefficient of proportionality is

$$\alpha = \frac{1{,}758}{1{,}470} = 1.20,$$

we obtain for the Quebec bridge

$$g = 22{,}900 \times 1.20 = 27{,}500 \text{ pounds per foot.}$$

I. Cables with Girder.

The greatest bending moment of the girder is given by $M = 0.019\,pL^2 = 0.019 \times 16{,}000 \times 1{,}758^2 = 939{,}531{,}000$ pounds × feet = 939,531,000 × 12 pounds × inches.

In case the permissible stress in the girder is $K = 40{,}000$ pounds per square inch (material—nickelsteel.) the necessary moment of resistance is

$$W = \frac{M}{K} = \frac{939{,}531{,}000 \times 12}{40{,}000} = 281{,}856 \text{ inches}^3.$$

The necessary cross-section of chord metal

$$F = \frac{W}{K} = \frac{281{,}856}{50 \times 12} = 470 \text{ square inches}$$

if the height of the girder in feet is 50.

The height of the catenary $f_1 = 175$ feet.

The tangent of the angle of slope of the outermost member of the catenary is:

$$\tan\alpha = \frac{350}{879} = 0.398$$

$$\cos\alpha = 0.929.$$

The greatest tension in the cable (for both girders)

$$S_{max} = \frac{(g+p)L^2}{8f_1}\cdot\frac{1}{\cos\alpha}$$

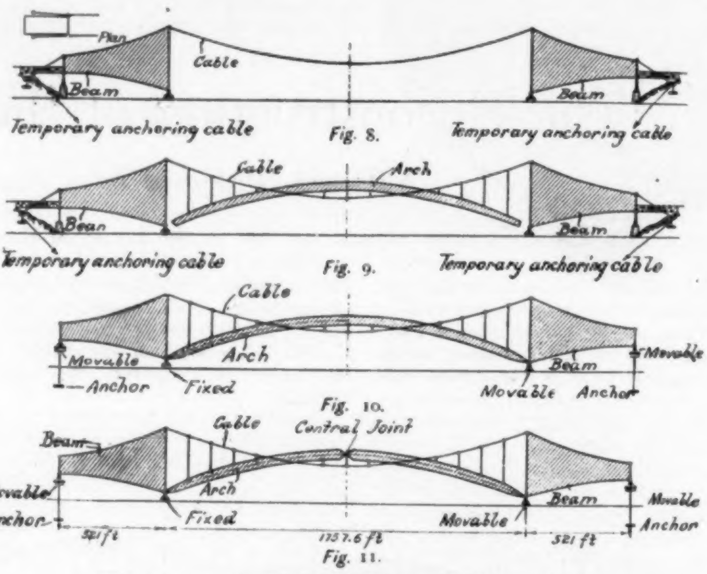
$$= \frac{(27{,}500 + 16{,}000) \times 1758^2}{8 \times 175 \times 0.929} = 103{,}367{,}000 \text{ pounds.}$$

The necessary cross-section of the cable, in case the permissible stress is 60,000 pounds per square inch (material—crucible steel), is given by

$$F_1 = \frac{103{,}367{,}000}{60{,}000} = 1{,}723 \text{ square inches.}$$

For one cable

$$F = \frac{1{,}723}{2} = 861.5 \text{ square inches.}$$



Figs. 8, 9, 10, 11.—Procedure in Assembling the Bridge.

The diameter of the cable, assuming solid cross-section, $d = 33$ *inches.*

II. Cables With Arch.

The greatest stress in the catenary is given by

$$S_{max} = \frac{(g_0 + g_c + p)L^2}{8(f_1 + f_2)}\cdot\frac{1}{\cos\alpha},$$

in which

$g_0 = 21{,}600$ pounds per foot, the weight without the cable,

g_c = the unknown weight of the cable,

$p = 16{,}000$ pounds per foot, the live load,

$f_1 = 175$ feet, the height of the catenary,

$f_2 = 200$ feet, the height of the arch.

The weight of the cable may be expressed by the following formula:[3]

$$g_c = \left(\frac{F \text{ sq. in.}}{12 \times 12} \times 1 \text{ ft.}\right) \times 490 \text{ lbs.} = \frac{S \times 490}{60{,}000 \times 12 \times 12}$$

where for F the value $F = \frac{S}{K} = \frac{S}{60{,}000}$ has been inserted.

If we insert the value for g_c thus found in the previous formula, we obtain:

$$S = \frac{(g_0 + p)L^2}{8(f_1 + f_2)\cos\alpha - \frac{490L^2}{60{,}000 \times 12 \times 12}}$$

$$= \frac{(21{,}600 + 16{,}000) \times 1758^2}{8(175 + 200) \times 0.929 - \frac{490 \times 1758^2}{60{,}000 \times 12 \times 12}}$$

= 44, 489, 000 pounds.

The necessary cross-section of two cables is

$$T = \frac{44{,}489{,}000}{60{,}000} = 741 \text{ square inches.}$$

For one cable

$$F = \frac{741}{2} = 350.5 \text{ square inches.}$$

which gives as the diameter of the cable

$$d = 21.8 \text{ inches.}$$

The length of the cable in the central span

$$2s = 2y\left[1 + \frac{2}{3}\left(\frac{x}{y}\right)^2\right] = 2 \times 879\left[1 + \frac{2}{3}\left(\frac{175}{879}\right)^2\right]$$

$$= 1{,}758 \times 1.026 = 1{,}803 \text{ feet.}$$

In addition, in the side spans 533 feet each, and in the anchor cables 200 feet each; in all

$$Z = 1{,}803 + 533 \times 2 + 200 \times 2 = 3{,}269 \text{ feet.}$$

The saving in weight of the cable

$$3{,}269 \times \frac{(1{,}723 - 741)}{12 \times 12} \times 490 = 10{,}923{,}000 \text{ pounds}$$

(= 4,950 metric tons).

[2] For a parabolic cable $H = \frac{qL^2}{8f_1}$

[3] 1 cubic foot = 0.0283 c. b. m.
1 cubic foot of cast steel weighs 490 pounds.

If we assume that the price of the cable, including transportation charges, amounts to \$125 for 1,000 pounds, we have for the saving 10,923 × \$125 = \$1,365,000.

In this manner it is possible to attain by the application of the proposed system a saving in cable alone of \$1,365,000.

CONCLUSION.

From the preceding description and calculation it is apparent, that through the application of the system proposed by the author, consisting of a catenary with an arch, it would have been possible not only to have attained an enormous saving but also to have gained a number of additional advantages, as follows:

1. The advantage of a greater strength of the bridge in a sidewise direction.

2. The possibility of employing semi-diagonals, in which the stress is half as great as in the case of diagonals.

3. The possibility of employing such a system of cross diagonals, which without rendering the girder statically indeterminate, would cause the diagonals to be subjected to half the usual tension.

4. The application of auxiliary diagonals in the side spans and the horizontal ties, by means of which the sum of the compression members would be reduced by one half.

Unfortunately the commission overlooked all this, and without having arrived at a comprehension of the project, gave its uncalled for opinion respecting the difficulty of designing movable supports upon rollers.

Metal Fakes

How the Unwary Buyer is Deceived

There are, of course, in the scrap metal trade (as in every other trade) a number of unscrupulous men, and it behooves the honest ones to be continually on their guard against being taken in. The following, according to *The Brass World*, are some of the methods employed to deceive the unwary buyer:

SENDING YELLOW BRASS CHIPS.

A dodge that seems to be frequently worked consists in mixing a certain amount (as much as the chips will stand) with yellow sand. In this way the scrap metal man obtains brass prices for sand.

As sand, if mixed with the chips direct, would be noticeable the following method is carried out to overcome it: Scrap bronze powder is easily obtained in the scrap metal market, and is the sweepings, etc., produced in the manufacture of bronze powder. It is very fine and slightly greasy. It readily adheres to anything, except wet material. The sand is dried and then mixed with a small quantity of the bronze powder. This coats them over. The bronze powder is practically the same color as the brass. In reality it is made from yellow brass, and is not bronze at all, although so called. It is also cheaper than the brass chips.

The sand, when covered with the bronze powder, is mixed with the chips and is then entirely concealed. The usual amount of sand to mix with the chips is about 10 per cent, and when added to them it is very difficult to see it. Those who purchase the chips, therefore, obtain the sand at the price of the chips. To look at a pile of chips of this kind, one would say that they were of good quality.

The method of ascertaining this deception is to take some of the chips and examine them. As yellow brass chips are usually fine, the sand is not readily seen, although the particles may be detected if they are spread out on a paper. The usual method, however, and one that is absolutely certain, is to take a small quantity of the chips, soak out the oil and grease in benzine or gasoline so that acid will act upon them, and then dissolve (in a porcelain dish) in dilute nitric acid. One part of the strong acid and one part of water are used. The chips will dissolve and leave the sand.

MIXING RED GRINDINGS WITH COMPOSITION CHIPS.

Composition chips command a comparatively high price as compared with red grindings. The latter, of course, result from the grinding of composition castings on an emery wheel, and contain a considerable amount of emery and molding sand from the foundry.

If composition chips and red grindings are mixed in the ordinary manner, the two will separate when shipped on account of the difference in size. In order to prevent this some American dealers of the lower class have been known to coat the chips over with molasses and then mix them with the grindings. In this manner the two will adhere and will not separate in shipping.

In using the molasses in this manner it is possible to mix from 5 to 10 per cent (or even more) of red grindings with the chips without being conspicuous, and unless the purchaser is forewarned he will not usually detect it. As there is a considerable difference in value between the chips and the red grindings this is a deception to be guarded against.

SPURIOUS CASTINGS.

Buyers are usually willing to believe the best of castings. In the case of composition castings they assume that if the metal was once cast, is red, and has been in use, it must be good. Hence they do not hesitate to purchase any form of composition casting.

Unscrupulous people have taken advantage of this fact to carry out a very careful deception.

Washings, railroad chips mixed with babbitt metal, or other form of scrap, that is, of such a character that a brass founder would never think of using it for making castings, are melted and cast into various common shapes found in the trade. As it would hardly pay to make valves or other complicated castings (although there are instances in which it might be done), simple castings only are made. One of the favorite shapes is large rings of the shape of a bearing. When cast, these are broken up and then are ready for sale.

The buyer, having such broken castings offered to him, at once believes that they were originally in use, were out, and were discarded. He files them, and they show red metal. Consequently he believes that the castings are of good metal. The more ingenuity has been displayed in making the castings in forms that will serve to indicate that good metal had been used in them, the more the buyer will be deceived. The discovery of this method of making "scrap composition castings" leads one to believe that "all is not gold that glitters."

PICKLING WASHINGS.

The term "washings" is used to designate the metal left in washing out the coal and slag from brass foundry ashes. Washings of this kind, when they come from brass foundries making red metal castings alone (such as, for example, steam metal valves), are always a desirable material, and can be used in the making of composition castings.

As such washings have usually been sold by the appearance, it is customary to wash them quite clean, and then, if they are entirely uniform in color and red, they command a good price. If, however, they are mixed with yellow brass washings, even in a small amount, the yellow color is so conspicuous that the whole material cannot be sold for red washings, but comes under the head of "mixed washings," and the price which they will brings is much lower.

In order to change the color of these metal washings before they are mixed with the red ones, they are sometimes "pickled." By doing this the surface of the yellow metal is changed to red. The method followed is simply to pickle the yellow washings in weak sulphuric acid (oil of vitriol). About nine parts of water and one part of sulphuric acid are used. The washings are immersed in it until the zinc in the brass is dissolved out, leaving the copper on the surface. This, of course, takes place only superficially, but still it is sufficient to color the washings. The pickling operation may take several hours if the pickle is cold, but if hot it acts very rapidly and the red color is obtained in a few minutes. The washings are then rinsed in water, and they will have a red color.

The yellow brass washings thus colored red on the surface are mixed with the red washings so that the whole lot has a uniform red color. The practice is, according to our contemporary, legitimate in one way, but is dangerous in another. Yellow washings are now rarely good on account of the extensive use of aluminium in making yellow brass castings. Aluminium is never used in the red metals. By thus mixing the yellow washings with the red, aluminium may be introduced. Were it not for the aluminium the red washings might melt to a red ingot, even though containing a small amount of yellow metal, but the presence of aluminium ruins the whole lot for any purpose that can be found for red brass except the cheapest class of railroad work, and even in this it cannot always be used.

Measuring the Height of an Aeroplane

The following method is applicable to the measurement of the altitude of any object and does not involve trigonometrical computations.

Cut from a sheet of heavy bristol board two square pieces, each exactly ten inches along the side. Tie the end of a four-foot length of heavy thread around a pin and drive the pin into the corner of one of the board squares. Start the pin in the edge of the bristol board at the extreme corner and drive it toward the center of the square so that only the head of the pin shows when driven in. Attach a pin and thread to the other square in exactly the same manner. Tie to the free end of each thread a heavy nail.

Thrust two sticks into the ground just one hundred feet apart as measured with a tape and tying the end of a cord around one stick carry the cord to and around the other stick, then back to and around the first, and so continue until five complete circuits have been made, and one thousand feet of cord measured off. Cut and wind the piece upon a bobbin for future use.

Preparations are now completed for measuring the altitude of an aeroplane, or of a cloud or mountain peak, for that matter. Assume that a large level field is available for operations and that measurements are to be made of the height of an aeroplane above the level of this field. Two observers establish themselves one thousand feet apart as measured by the prepared piece of cord. Observations are to be taken only when an imagined line drawn from observer number one to the aeroplane passes directly over the head of observer number two; in other words, when observer number one would see the aeroplane strike the ground *beyond* and in line with observer number two, if it were at the moment of observation to make a vertical descent. When the plane swings into this alignment each observer raises his square and holds it with its faces vertical, the weighted thread hanging from the highest corner. Then with the right eye each sights at the plane along the upper edge of his square as if he were aiming at the plane with a rifle, the upper edge of the square representing the rifle barrel (Fig. 1). At the same time the thread must hang freely, yet at rest, along the left face of the square. Still holding a perfect sight on the

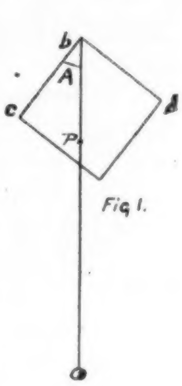


Fig 1.

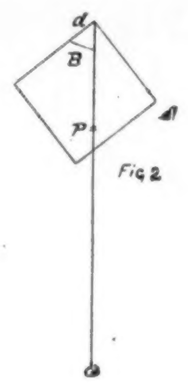


Fig 2

plane, press the hanging thread with the thumb of the left hand carefully and firmly against the face of the square. With a sharp pencil, mark on the board the position of the thread by the intersection of the arms of a cross as at P (Figs. 1 and 2). It is evident that the more distant observer sees the plane at an angle of elevation measured by the angle A (Fig. 1), while the nearer observer notes a larger angle B (Fig. 2).

Next, bring the card board squares together and place them upon a large table, or a floor, edge to edge, with the corner C at the corner d (Figs. 1, 2, and 3). Stretch each thread into its former position across its marked point P. The threads will cross at some point m (Fig. 3). The points b, d, and m form a reduced size picture of the positions of the two observers and the

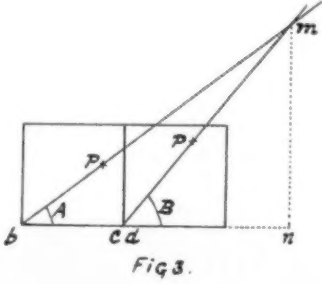
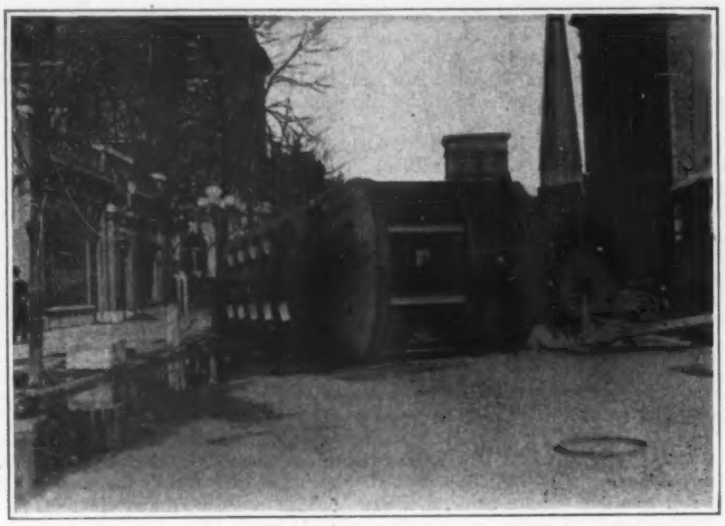


Fig 3.

plane, respectively, where the length of the line $m\ n$ corresponds to the height of the plane. Point n is the foot of the perpendicular dropped from m upon the line $b\ d$ produced. If the length of line $m\ n$ be twenty inches, or twice the length of $b\ d$ (which is ten inches) then the height of the plane is twice the distance between the two observers, or twice a thousand feet. In short, the height of the plane is as many hundreds of feet as is the length of $m\ n$ in inches. If $m\ n$ be twenty-six and one half inches, the plane is twenty-six hundred and fifty feet high.

To measure the height of most clouds the observers would do well to place themselves one mile apart on a straight and level road and take observations when the cloud comes into line above the road. In this case, one tenth of the number of inches contained in the line $m\ n$ is the height of the cloud in miles. If $m\ n$ be forty-five inches, the cloud is four and a half miles high. Further, if the distance $d\ n$ (Fig. 3) be, say, thirty-five inches, the nearer observer would have to walk forward three and one half miles before finding the cloud directly above him.



A Trolley Car Washed Along Third Street, Dayton, for Half a Mile by the Strength of the Flood Current.

Many Homes Were Lost in This Street at Hamilton, Ohio. The Flood Tore up the Pavement and Dug a Channel Ten Feet Deep.

The Rainfall and Flood Conditions in Ohio, March 23 to 28, 1913

Special Report Prepared for the Weather Bureau

By Prof. J. Warren Smith

THE rainfall data now available are generally complete and the figures are correct. The river-gage stages may be subject to some corrections because in most cases the river was so high that the gages could not be read exactly and in a number of cases the river gage was carried away and the readings are estimated. The highest point has been marked, however, and careful leveling will be done as soon as possible to determine the exact heights reached.

THE RAINFALL.

Rain began to fall in extreme northwestern Ohio at about 8 A. M., Sunday, March 23rd, and in central counties during the middle or latter part of the forenoon, although in extreme southeastern districts it did not begin until the afternoon of the 24th.

The rainfall during the first 12 hours, or up to the evening of the 23rd, was from one half inch in central Ohio to over 2.5 inches in northwestern counties.

It continued during Sunday night, so that by the morning of the 24th the 24-hour fall was slightly over 3.0 inches in the Sandusky River valley, and nearly 3.0 inches at Piqua, in the Great Miami valley.

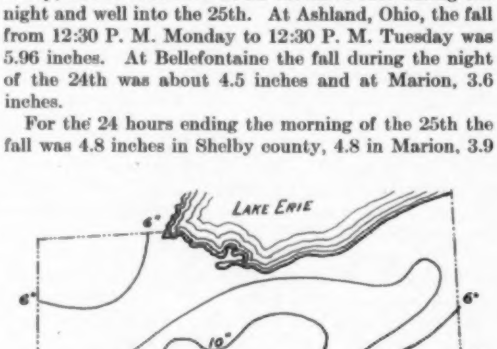
During the day of the 24th the rainfall amounted to 3.7 inches at Piqua and 2.5 inches at Dayton, although it was not so heavy in other sections. The rainfall for the 24 hours ending on the evening of the 24th was 5.6 inches in Miami county, 2.9 in Montgomery, 3.2 in Preble, and from 1.5 to over 2.0 inches from those counties northeastward across all the central counties; it was about 1.0 inch in extreme northwestern and less than one fourth inch in extreme southeastern counties.

TOTAL RAINFALL TO THE EVENING OF THE 24TH.

The total fall up to late Monday afternoon was 6.7 inches in Miami county, over 4.0 inches in Preble, Hancock, Henry, and Wyandot counties, and was over 3.0 inches over most of the northwestern half of the State.

During the afternoon of the 24th the rain was especially heavy, and it continued at an excessive rate during the night and well into the 25th. At Ashland, Ohio, the fall from 12:30 P. M. Monday to 12:30 P. M. Tuesday was 5.96 inches. At Bellefontaine the fall during the night of the 24th was about 4.5 inches and at Marion, 3.6 inches.

For the 24 hours ending the morning of the 25th the fall was 4.8 inches in Shelby county, 4.8 in Marion, 3.9



Map Showing Total Precipitation from March 23rd to March 27th in Flood District.

in Wyandot, 5.0 in Richland, 3.6 in Wayne, 4.8 in Summit, and then gradually less on each side of this line of counties. It was estimated to be 9.0 inches at Piqua.

During the 25th the rainfall decreased somewhat in northwestern districts, but was heavier in southern counties. The total fall for the 25 hours ending the evening of the 25th was 4.4 inches in Darke county, 3.9 in Shelby, 5.6 Logan, 4.4 Marion, 3.4 Crawford, 5.2 Richland, 4.8 Wayne, 3.8 Holmes, 4.3 Summit, 4.6 Portage, 3.9 Trumbull, and then decreasing gradually to 1.4 in Williams county in the northwest and to 0.4 in Lawrence county in the extreme south.

The heaviest rainfall moved still farther toward the southeast on the night of the 26th, so that the fall for the 24 hours ending the morning of the 26th was only 0.3 in Lucas county, 1.3 Shelby, and 2.1 in Marion, but was 4.1 in Warren, 3.4 in Pickaway, and 3.0 inches in Muskingum counties.

TOTAL FALL UP TO THE MORNING OF THE 26TH.

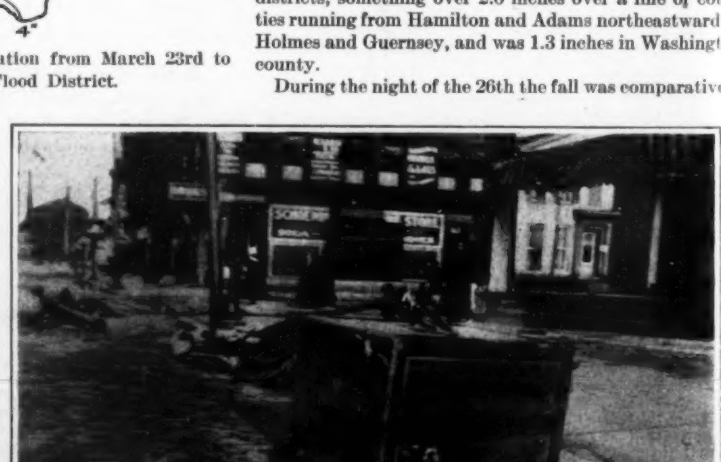
The river was over 40 feet at Zanesville on Wednesday morning, the 26th, and the Muskingum River reached about 15 feet higher than ever before known from Zanesville south during the next 36 hours.

The total rainfall up to the morning of the 26th was 8.2 inches in Richland county, 7.2 in Wayne, 6.2 in Stark, 6.4 in Licking, and 5.2 in Muskingum. It was 8.4 in Wyandot, 9.1 in Marion, 5.9 in Franklin, 5.9 in Pickaway, 7.3 in Warren, and 3.1 in Hamilton counties.

The fall for the 24 hours ending the evening of the 26th was less than one fourth inch in the extreme northwestern districts, something over 2.0 inches over a line of counties running from Hamilton and Adams northeastward to Holmes and Guernsey, and was 1.3 inches in Washington county.

During the night of the 26th the fall was comparatively

John Walsh, in His Improvised Raft, Which He Employed in Rescuing a Number of Dayton Flood Victims.



A Three-ton Safe Rolled and Tumbled Along Jefferson Street for a Mile by the Flood, Which Ran to 9 Feet at This Point. (Dayton.)

Pontoon Bridge Built by the Militia Across the Miami River to Connect East and West Hamilton After the Bridges Had Been Washed Away.

View Looking Up Vine Street, Cincinnati, as it Appeared During the Biggest Flood Ever Experienced by That City.

light, and for the 24 hours ending the morning of the 27th it was generally from 0.7 inch to 1.5 inches.

It was light also during the 27th, so that the total for the 24 hours ending the evening of the 27th was less than 1.0 inch, except in a few instances.

TOTAL RAINFALL FOR 48 HOURS.

It was the almost unprecedented rainfall for the 48 hours ending Tuesday morning, the 25th, that caused the extremely high water in the Great Miami, Scioto, and Sandusky rivers.

In Logan county the fall up to the morning of the 25th was 7.4 inches, Marion 7.0, Shelby 6.6, Richland 6.0, Summit, 6.6, Wyandot 6.9, Seneca 6.7, Sandusky 6.2, Lucas 5.1, Cuyahoga 2.8, Stark 3.2, Coshocton 2.7, Licking 3.3, Franklin 3.2, Warren 3.6, Hamilton 2.6, decreasing toward the southeast.

At Piqua, Miami county, the total fall up to midnight of the 24th was 8.3 inches.

The total for the 48 hours ending the morning of the 26th was greater in central and southeastern districts and lighter in northwestern districts.

The rainfall for the 48 hours ending the evening of the 25th was 7.1 inches in Preble county, 6.2 in Darke and Montgomery, 7.1 Logan, 6.4 Marion, 7.2 Richland, 6.8 Wayne, 6.0 Summit, and then decreasing gradually to 2.2 in Williams county and 0.8 inch in Washington county.

The fall for the 48 hours ending the evening of the 26th was about 2.0 inches in the extreme northwest, from 2.0 to 3.0 inches in the southeast, and from 5.0 to over 7,0 inches over about one third of the State running from the southwestern to the northeastern counties.

The accompanying table shows the rainfall for each 24 hours from March 23rd to 27th, 1913, and also for March 19th to 23rd, inclusive, 1898. These figures are given for 1898 because the rainfall during that period caused the highest water in the Muskingum and lower Scioto rivers previous to 1913.

At Youngstown, on the Mahoning River, the gage reading was 22.9 feet, or 7.1 feet higher than ever before recorded, and at Defiance, on the Maumee River, about 28.0, or nearly 12.0 feet higher than ever before known.

Practically every stream in Ohio was reported higher than ever previously recorded.

On the page opposite the total rainfall for the period from March 23rd to March 27th in the district affected by the recent flood is shown graphically by means of contour lines.

DAILY RAINFALL IN OHIO.

Watersheds.	MARCH 23RD TO 27TH, 1913.						MARCH 19TH TO 23RD, 1898.					
	23	24	25	26	27	Total.	19	20	21	22	23	Total.
Lake Erie:												
Benton Ridge	2.4	2.0	2.6	0.2	0.3	7.5	..	..	..	..	..	...
Bucyrus	1.4	2.1	3.4	1.6	1.2	9.7	..	..	..	..	..	...
Cleveland	1.9	1.5	2.7	0.9	0.2	7.2	1.5	0.1	..	0.6	0.2	2.4
Ottawa	2.0	1.2	2.7	0.4	0.2	6.5	0.3	0.1	0.2	1.0	0.2	1.8
Sandusky	2.2	1.6	2.0	1.0	0.4	7.2	2.7	0.1	0.1	0.8	0.3	4.0
Tiffin	2.0	1.1	3.6	0.5	0.8	8.0	0.5	..	0.1	1.0	0.1	1.7
Toledo	1.9	1.8	1.7	0.5	0.2	6.1	1.4	..	0.1	0.5	..	2.0
Wauseon	2.1	1.1	1.8	0.3	0.3	5.6	2.5	..	0.1	1.1	..	3.7
Ohio:												
Bangorville	0.9	2.0	5.2	1.6	0.9	10.6	1.1	..	0.4	1.2	2.4	5.1
Canal Dover	0.6	0.3	2.7	1.4	0.8	5.8	0.7	1.0	0.5	1.4	2.5	6.1
Canton	1.0	2.2	3.0	1.6	0.6	8.4	..	0.8	0.3	1.0	2.1	4.2
Granville	0.5	1.4	2.7	2.1	0.5	7.2	0.7	0.4	0.7	2.2	0.8	4.8
Marietta	0.2	0.1	0.7	1.3	0.4	2.7	..	1.3	1.0	0.2	0.6	3.1
Millport	0.8	0.9	1.9	1.4	0.7	5.7	0.6	0.5	0.4	1.4	1.6	4.5
Philo	0.4	1.4	1.5	2.3	0.7	6.3	..	0.8	0.8	0.4	1.2	3.2
Warren	1.7	1.8	2.9	1.4	0.5	8.3	0.9	0.3	0.2	0.6	0.8	2.8
Wooster	1.2	1.9	4.8	1.4	0.8	10.1	0.4	0.6	0.4	1.0	1.5	3.9
Circleville	0.2	1.5	2.0	2.3	0.4	6.4	0.3	0.9	0.8	0.3	1.4	3.7
Columbus	0.5	2.1	2.9	1.4	..	6.9	0.5	0.5	0.7	1.4	1.6	4.7
Delaware	1.1	2.0	2.5	1.9	..	7.5	..	..	..	..	..	..
Marion	1.4	2.0	4.4	1.9	1.0	10.7	0.8	..	0.5	1.8	1.3	4.4
Waverly	..	0.3	1.3	2.6	0.4	4.6	0.5	0.1	1.0	0.1	0.3	2.0
Bellefontaine	1.4	1.5	5.6	2.1	0.5	11.1	..	..	..	..	..	..
Cincinnati	..	2.2	4.2	1.1	..	7.5	0.1	0.8	0.8	..	0.7	2.4
Dayton (Boyer)	0.5	2.9	3.3	1.5	0.8	9.0	1.0	0.4	0.8	0.5	1.2	3.9
Greenville	1.3	1.8	4.4	1.4	0.4	9.3	0.4	0.5	0.7	0.9	2.3	4.8
Sidney	1.3	1.8	4.0	1.3	0.4	8.8	..	..	..	..	..	..
Urbana	0.6	2.1	3.1	2.2	0.5	8.5	..	..	..	..	..	..
Waynesville	0.4	2.2	2.6	2.3	0.3	7.8	..	..	..	..	..	..

Tangled Mass of Dress Goods and Ribbons Wrapped Around Fire Plug and Light Pole by the Flood. (Dayton.)

A Counter Washed Half Way Through the Plate Glass Window of a Restaurant in Second Street, Dayton.

The Structure of the Atom—VI*

The Physical and Chemical Properties of the Atom Explained in the Light of Modern Theory and Experiment

By Sir J. J. Thomson, F.R.S.

Concluded from Scientific American Supplement No. 1948, page 287, May 3, 1913

I wish to begin by considering the bearing of the phenomena of radiation on the problem of atomic structure. The radiation emitted by bodies covers an extraordinarily wide range. The wave-length of the "characteristic" Röntgen rays, for example, is less than the diameter of the atom itself, being about 10^{-9} centimeters, while at the other end of the spectrum we have evidence that certain liquids, such as water, give forth radiations of which the wave-length is as great as half a meter. This is shown by the fact that water and other liquids containing the hydroxyl radicle absorb electric waves of this length, and must therefore also emit them. Confining our attention, however, to the waves of the visible spectrum, or having wave-lengths of the same order, we have an immense accumulation of data, the work of spectroscopists for a period of half a century. The light thrown by these on atomic structure has not, however, been so far very definite. There are, however, at last indications that the study of the light emitted by the atom under varying conditions will prove an important aid to the study of its constitution.

What is the nature of the "lamps" which emit the radiation in question? A cursory study by the spectroscope shows that there are two quite distinct classes of spectra. Of these, the one type consists of a number of separate and fairly sharp lines. By using sufficiently high dispersion these "lines" can, in most cases, be resolved into aggregates of finer lines very close together. The other type of spectrum is known as a band spectrum, each band resembling a discontinuous patch of a continuous spectrum. A spectroscope of great dispersion, however, resolves these bands into a large number of separate lines.

The band spectrum is the only type that is known to be emitted by a compound body. No compound, in fact, gives a line spectrum, but always one of the banded type, which is distinguished from a line spectrum by a number of peculiarities. The position of the lines in the line spectrum is, for example, affected by a magnetic field, Zeeman having shown that practically all the lines are shifted by a magnetic field. In the band spectrum, on the other hand, a magnet has apparently no effect at all, the bands remaining in the same position when subjected to a magnetic field as when this field is absent.

It is not only compounds which give rise to band spectra. Many elements, in fact, give band spectra in addition to line spectra. This leads to the conclusion that the band spectra are due to the molecule, and not to the atom, and that they arise from the influence on each other of the neighboring atoms forming the molecule. If the view is taken that the bands are due to the vibrations of systems consisting of more than the atom—that is to say, to the vibration of two atoms with reference to each other, or of one atom with reference to the others in a compound molecule—we can understand that the spectra should be different. Matter ordinarily consists of molecules, and the band spectrum being due to the molecule, it is this type of spectrum, and not the line spectrum, which is given out by matter in its normal state. Gaseous oxygen, for example, consists of molecules, and hence, if light is sent through this gas, there is an absorption of vibrations due to the molecules; that is to say, of what corresponded to the band spectrum of oxygen. On the other hand, oxygen in its normal state will not absorb light corresponding to its line spectrum. The latter is due to vibrations of the isolated atoms, which do not exist as such in ordinary oxygen gas. Another important point which arises is that no connection has been found between the bands of a banded spectrum and the lines of a line spectrum, it being impossible to associate the spectrum of the molecule of a compound with that corresponding to the atoms of any of its elements.

If, on the other hand, instead of the banded spectrum we take the Röntgen-ray spectrum, it is possible to predict, from that of the component elements, the complete character of this characteristic radiation, since the spectrum derived from the core of an atom is maintained unaltered in all the atom's combinations. Band spectra, on the other hand, being derived from the motion of one part of a molecule relatively to the other, can not be predicted from the vibrations sent out by the free atom.

¶ If, as assumed, the bands are derived from the molecule, band spectra should be more easily excited than is the line spectrum, which necessarily involved the splitting up of the atom; and this is found to be the case. Experiments made by Mr. Fulcher on the spectra produced when cathode particles are sent at various speeds through air and through hydrogen show this very clearly. Fulcher found that when the speed of the particles was very slow, due to, say, a fall through 30 volts, nitrogen gave out its "positive" band spectrum. If the speed of the cathode particles was increased to that due to a fall through 60 volts, he got, in addition, the "negative" band, and by using very high-speed particles he got both sets of bands and also the line spectrum.

A mere inspection of the line spectrum shows that there is an enormous multitude of these lines, amounting in some cases to thousands. Practically all of these are known to be affected by a magnetic field, and this shows that they are due to the small negative corpuscles, as only these are light enough to be sensibly affected by the field. These corpuscles therefore give rise to thousands of vibrations. If the ordinary view is taken that the number of such particles corresponds to the number of lines in the spectra, we should have in the atom a number of corpuscles far in excess of what has been shown to be possible. Moreover, there is reason to believe that the spectral lines are not merely numerous, but that the number of them is really infinite. In recent years a very remarkable connection has been revealed between these various lines, which, it turns out, are not distributed haphazard, but are interconnected by simple numerical laws.

In a vibrating string, as is well known, all the harmonics are connected together in a simple numerical relationship, and many attempts have been made to discover similar harmonics in the spectra, but every such attempt has failed. Nevertheless, Balmer has found, for hydrogen, a most interesting connection, of another kind, between the lines. Balmer's law is, perhaps, the most remarkable empirical formula in the whole of physics, being so accurate that spectroscopists now use it to correct their actual observations. Balmer found that the wave-lengths of the various lines in hydrogen are all represented by the formula

$$\lambda = A\frac{m^2}{m^2-4},$$

where λ denoted the wave-length, A a constant, and m any integer. This formula gives the lines of the hydrogen spectrum with extraordinary precision, its accuracy, in fact, being in excess of our present powers of measurement.

If Balmer's formula is turned upside down, it can be written in the form

$$n = \frac{m^2-4}{m^2}\cdot\frac{1}{A},$$

where n denoted the number of vibrations per second, and this is equivalent to a formula of the type

$$n = C - \frac{A}{m^2}.$$

The point which at once arises is where is this formula to stop? If m can be any integer, it follows that the number of lines of the spectrum may be infinite.

Formulæ of this kind have been used to dissect the spectra of most of the elements. Rydberg, for example, has given the form

$$n = C - \frac{A}{[m+\mu]^2}.$$

where μ denotes a constant. A remarkable point about this formula is that A is apparently the same for all elements, and the fact that this is an absolute constant is most suggestive. The problem which remains is to find a system, the vibrations of which would be in correspondence with the formulæ, and the search for this has not yet proved very successful. The only one brought forward so far is a very ingenious suggestion due to Ritz, but this has not sufficient physical probability to make it very satisfactory.

Ritz's idea was that the vibrations which give rise to the spectra of hydrogen are not due to to-and-fro oscillations, like that of a spring, but to the motion of particles in circles described under the action of magnetic forces. The periodicity in such a case depends upon the value of $\frac{He}{m}$, where H is the strength of the magnetic field, e the charge carried by the particle, and m its mass. In Ritz's view the vibrations are analogous to those of a conical pendulum. The number of revolutions per second is just proportional to the strength of the magnetic field, and it is necessary, therefore, to get this magnetic force inside of the atom. Ritz assumed, therefore, the existence of a lot of little elementary magnets, each of the same length and of the same force.

Assuming that there was one such elementary magnet in the atom, and that a particle was distant by a length a from its nearer pole, then the force exerted by this pole would be $\frac{m}{a^2}$. If l were the length of the magnet, then the force exerted by the other pole would be equal to $\frac{m}{(a+l)^2}$.

If now a second elementary magnet were strung on below the first, the force exerted by the farthest pole would be $\frac{1}{(a+2l)^2}$, and if a third magnet were added, it would be $\frac{m}{(a+3l)^2}$, and so on.

The formula for the strength of the magnetic field thus obtained is of the exact type needed to correspond with Rydberg's formula; but from physical considerations the proposed system is too improbable to make one feel much satisfaction with it.

Nevertheless, I think there is a good deal to be said for the view that the lines are produced by vibrations of the conical pendulum type, a theory which to a large extent would get rid of the difficulty of correlating the number of the spectral lines with the number of the corpuscles. A conical pendulum might be said to have a great number of periods. A ball hung by a string from a fixed point would, if started properly, describe a circular path; but to get this result it is necessary to start it in a special way. If this is not done, it will pursue a meandering path, which, mathematically considered, is not periodic. The bob would, in fact, trace a path always comprised between an inner and an outer circle, which it touched alternately. If properly started, however, the bob would never leave the outer of these two circles, and this constitutes the simplest case. If, however, this circular orb were not hit off, the bob would take, as stated, a meandering path, of which an infinite number are possible, the whole being comprised between two limiting circles, as stated. Of this infinitude of paths, some have a certain periodicity, the ball returning to its initial position after describing a certain number of loops. Hence, of the infinite number of paths possible to a conical pendulum, there are certain in which the motion recurs with a greater periodicity, and it is just possible that in this way we might find series corresponding to those of Rydberg.

Much light has been thrown on the origin of spectra by a method due to Stark in his study of the positive rays. In such rays we have a mixture of ions which might, for instance, be hydrogen atoms, hydrogen molecules, molecules of CO_2, atoms of carbon, or atoms and molecules of other gases carrying one or more positive charges. These positive rays give out considerable luminosity. If it is the positive rays themselves which give out the light, this light, when examined in the spectroscope, should show the Döppler effect, since the particles are moving with very high velocities. Hence, if viewed from a point toward which they are moving, the spectrum should be shifted toward the blue, and *vice versa*. This has been proved to be actually the case by Stark, who has found that all the hydrogen lines, for example, are displaced by an amount corresponding to about the same velocity. This observation shows that the hydrogen atom is the origin of the hydrogen lines. The method is in its infancy, but it should enable us to find out much about the different lines, in view of the fact that the different ions in the positive rays can all be separated the one from the other by means of a magnetic field. It should thus be possible to find, by observing the Döppler effect, what lines, for instance, are due to CO, and what to the carbon atom by itself. There is here, I think, the foundation of a great extension to our knowledge of the spectrum.

One point not yet settled is whether the lines of hydrogen originate while that atom carries its positive charge, or after it has become neutral by seizing a negative charge. Both views are advocated, and each school has made experiments which each thinks completely confirm its own contention. My opinion is that the vibrations are given out by the positively charged atom in the very act of regaining a negative particle, and that it is not so probable that the spectrum is emitted while the particle is actually positively electrified. All the lines, in fact, show the Zeeman effect, and must, therefore, be due to negative corpuscles. The view above stated is not, I think, inconsistent with any of the experiments yet made. I do not, however, mean to say that the atom would have been able to give out its spectrum if it had not been positively charged. That something equivalent to this must

*Concluding lecture of the series delivered before the Royal Institution and reported in *Engineering*.

have occurred is proved by the fact that the spectrum of helium is not absorbed by ordinary helium; but I think that it would be by helium when excited in a discharge-tube. The different ways in which the spectrum alters with the conditions of discharge is quite familiar to all spectroscopists. It is particularly well shown with argon.

Stark, in his examination of positive rays, has found that when these rays come through with two charges instead of one, the Rydberg series is altered.

To sum up, we have been led to regard the atom as built up of a large number of negative corpuscles mainly concentrated near the center of a corresponding mass of positive electricity, this aggregation forming the core of the atom. In this core the negative particles are very firmly held together, and when disturbed give out vibrations of very great frequency. In addition to these inner corpuscles, there are a number near the surface of the atom; these are not so firmly held, and on them depends the power of an atom to attach to itself others, and to form chemical compounds. The number of these surface atoms determines the atom's maximum valency. With one corpuscle we have an electropositive monovalent element, while two give a divalent element, and so on; the maximum number of these outer corpuscles being eight.

Coming to the core of the atom, the distribution of the positive electricity has to be considered. The negative electricity is divided up into corpuscles, and the radioactive bodies afford strong evidence that the positive charge is also made up into parcels, but much larger and more massive than those into which the negative charge is divided. Thus the α particles are atoms of helium carrying two positive charges. The radioactive atom, when it splits up, gives out these α particles, which is evidence that, at any rate, some of the positive parcels correspond in size to the helium atom. There must, however, be something else in the core. Part of the positive electricity may be in parcels corresponding to positively charged hydrogen atoms, or to some other aggregations of comparatively small atomic dimensions.

Thus the core may be regarded as made up as an aggregate of distinct units, one kind being, as stated, the α particle, while the others we are not yet sure about. Perhaps some light may be obtained by a very detailed study of the atomic weights. Among the lighter elements a remarkable difference in the chemical grouping is noticeable with each increase in the atomic weight. All numbers can be divided into four classes, of which one group is exactly divisible by 4, while in the others the remainder is 1, 2, or 3. If all numbers up to 40 are arranged thus in four columns, we get a table as that represented below. In this table, all numbers which have chemical elements corresponding to them are printed in Arabic numerals, and all numbers with which no known element corresponds, in Roman characters.

It will be noted that in the first and fourth columns there are only two numbers represented by Roman figures, while in the case of the two middle columns very few of the numbers correspond to the atomic weights of actual elements. From the fourth column it would seem that something with an atomic weight equal to 3 had a good deal to do with the constitution of the atom, but it should be observed that on extension of the series to the higher atomic weights we get into difficulties.

Again, if column No. 1 is studied, it will be seen that in general the grouping of the elements corresponds with the view that the gain of an α particle with atomic weight equal to 4 increases the order of the chemical group by 2. Helium with an atomic weight of 4 is in group No. 0, and carbon with an atomic weight of 12 in group No. 4. Oxygen with an atomic weight of 16 is in chemical group No. 6, while neon, with an atomic weight of 20, is in group No. 8, which is equivalent to group No. 0. A similar rule holds in general with respect to column 4, an increase of the atomic weight by 4 raising the chemical group by 2.

4 n.	4 n+1	4 n+2	4 n+3.
4	1	II.	3?
VIII.	V.	VI.	7
12	9	X.	11
16	XIII.	14	XV.
20	XVII.	XVIII.	19
24	XXI.	XXII	23
28	XXV	XXVI.	27
32	XXIX.	XXX.	31
36	XXXIII.	XXXIV.	35
40	XXXVII.	XXXVIII.	39

In concluding I might say that I fear my course of lectures has led to a very tentative view of the structure of the atom; but this view has been built up out of very new material, since neither the corpuscle nor the α particle was known to science twenty years ago, and I hope that future studies will afford the potentiality of explaining more adequately the very numerous properties of the atom.

The Weight Efficiency of Prime Movers

COMPARISONS as to the relation of weight to the output of prime movers have often formed the subject of theoretical investigation, and certain laws have been established which, when due allowance is made for adventitious disturbing factors, are found to be themselves in remarkable accordance with the actual facts. These laws show that to produce a given horse-power for the lowest possible weight, the number of units constituting the complete plant should be as large as possible. It is, in fact, perfectly safe to construct a small engine from the same drawings as a large one by simply altering the scale. By such a scaling-down the weight will de diminished in proportion to the cube of the scale of reduction, but the output need theoretically only be reduced in proportion to the square of this scale, and, as a consequence, the weight per brake horse-power of engines constructed with the same factor of safety should vary inversely as the cylinder diameter. In steam engine practice, however, small engines often weigh nearly as much per horse-power as large ones, a fact which is perhaps due to the circumstance that, owing to the low steam pressures available, and the low speeds of rotation adopted, even early steam engines were of relatively large dimensions. When higher speeds were subsequently adopted, certain dimensions had become more or less standardized. These were copied accordingly in designing the smaller engines, increasing their weight much beyond what was necessitated by considerations of strength. Another factor which has often tended to make small steam engines unnecessarily heavy for their output is the fact that they are frequently run at much lower piston speeds than are usual with large engines. High speeds of rotation involve greater care in the finish of the bearings, and in the provision made for insuring adequate lubrication, and it may therefore be cheaper to build the engine a little heavy for its output rather than provide for satisfactorily running it at a higher piston speed. When, however, a well-designed high-speed steam engine is compared with an equally well-designed slow-speed engine, the law that the weight per horse-power varies directly as the cylinder diameter seems to be in very satisfactory agreement with practice.

In his remarks on Dr. Diesel's paper at the recent meeting of the Institution of Mechanical Engineers, Mr. Dugald Clerk gave curves which show in a remarkable manner how very closely the above law applies in the case of gas engines for cylinder diameters up to 51¼ inches in diameter. This remarkable agreement between practice and theory seems to indicate that gas engines have been systematically designed with the same factor of safety in all sizes, and are being run up to about the limit of their capacity. In fact, at the recent meeting of the British Association at Portsmouth, Mr. W. A. Tookey stated that the usual practice was to rate such engines, not at the load which they could carry indefinitely, but at the maximum output which could be developed for a run of 15 to 30 minutes. Evidently these are just the conditions in which the law of similarity may well be expected to apply with substantial accuracy.

Hitherto comparisons of the weight efficiency of machinery have been made on the basis of power developed per ton of total weight, and on this foundation a rational law of similitude has been established, the results of which, as above stated, are in reasonable agreement with actual facts. In a paper read before the Institution of Electrical Engineers at Glasgow on April 11th, Mr. W. B. Hird proposes another method of comparing the weight efficiency of prime movers. He suggests that the comparison should be based on the torque developed per ton of material, and on this basis the slow-speed steam engine, the electric motor, and the water turbine make a very much better showing than high-speed machinery. Some of his results are given in the annexed table, which shows the horse-power per revolution obtained per ton with different motors for a range of values of

$$K = \frac{\text{B.H.P.}}{\text{revolutions per minute.}}$$

Table Showing the Horse-Power per Revolution Obtained in Different Types of Motors for 1 Ton of Material.

K.	Steam, Low Speed.	Engine, High Speed.	Gas-Engine.	Oil-Engine.	Steam-Turbine	Electric Motor.	Water Turbines, 30 ft. Head.	Turbines, 80 ft. Head.	Turbines, 200 ft. Head.
0.02	0.097	0.048	0.033	0.021	..	0.023			
0.10	0.099	0.052	0.034	0.027	0.014	0.057			
0.20	0.110	0.056	0.036	0.032	0.017	0.082	0.055	0.075	0.081
1.00	0.130	0.086	0.040	0.048	0.034	0.130	0.120	0.140	0.160
2.00	0.150	..	0.054	..	0.060	0.170	0.195	0.230	0.260

Such a method of comparison seems open to many objections. Some of these are relatively unimportant and equally applicable to any basis of comparison. For example, the same casing is sometimes used for two steam turbines, one developing 1,000 horse-power and the other 500. In such a case the total weights are practically the same, but the "weight efficiency" is greatly reduced with the smaller machine. Another minor objection is that different motors have different characteristics. With a gas engine the maximum torque possible at one revolution per minute is the same as when running at full speed, while with an electric motor the torque in actual practice, rises very rapidly as the speed decreases; and were this fact allowed for, the weight efficiency per unit of torque would be much greater than for any other form of prime mover.

These objections to Mr. Hird's proposal are, as stated, of minor importance; but one which seems fundamental is that torque as such has no market value. What a customer desires to purchase is power. Did he merely require torque, he could get it more easily and cheaply by hanging a weight at the end of a lever than by the acquisition of any form of prime mover. In other words, torque only becomes valuable when it is multiplied by angular velocity, and it is just this essential factor of the problem that is neglected in the proposed method of comparison.—*Engineering.*

Rabbits and Cats in Australia

OUR readers will remember that some years ago the rabbit was imported into Australia, which was at that time somewhat sparsely supplied with mammals. They will also remember how this step proved extremely injudicious, the rabbits multiplying with such speed that very soon they had become an intolerable nuisance. Seeking a remedy for this state of things the Australians then introduced the cat, setting it loose in the hope that it would prove an efficient enemy to the rabbit. According to the New South Wales Agricultural *Gazette*, this has been a step from the frying pan into the fire—for the cat has proved itself an active destroyer of all kinds of small game—with occasionally a rabbit thrown in. Our feline friend has prospered on this fare, for we read that some specimens have been found to weigh 20 pounds! And the worst of it is is that the cat has no enemy—out in the wilds of Australia, of course. Now dogs have been tried as an antidote for cats. One naturally asks what will be the next addition to Australia's troublesome fauna.—*La Nature.*

A New Vacuum Gage of Extreme Sensitiveness*

By Irving Langmuir

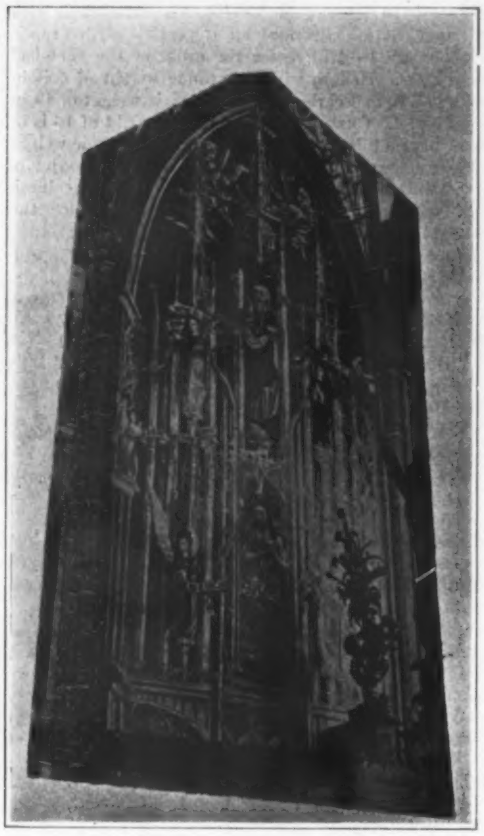
AT very low pressure the viscosity of gases is one of their most marked characteristics. This property is made use of in the new gage.

The gage consists of a rotating disk above which is suspended, by a quartz fiber, another disk carrying a mirror. The viscosity of the gas causes it to be set in motion by the lower disk and this motion produces a torque on the upper disk which can be measured in the usual way by a beam of light reflected from the mirror.

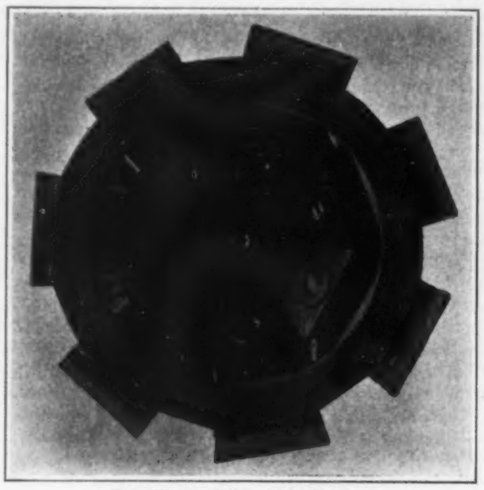
The rotating disk is made of thin aluminium and is attached to a steel or tungsten shaft mounted on jewel bearings and carrying a magnetic needle. The suspended disk is of very thin mica. The lower disk can be rotated easily at a speed of 10,000 revolutions per minute by means of a rotating magnetic field produced outside of the bulb containing the two disks. This field is most conveniently obtained by a Gramme ring supplied with current at six points from a commutating device run by a motor. In this way the speed of the motor determines absolutely the speed of the disk, since the two revolve in synchronism. The speed of the disk may thus be varied at will from a few revolutions per minute up to 10,000 or more.

The sensitiveness of the gage is extremely great. At 1,000 revolutions per minute, with a scale at about 60 centimeters distance, we obtain about 400 millimeters deflection for 0.001 millimeter of air. We find the deflection exactly proportional to the pressure below about 0.01 millimeters, proportional to the speed of the revolving disk and practically independent of the distance between the two disks. For different gases at the same pressure the deflections are proportional to the square root of the molecular weight. All these facts are in accord with the kinetic theory. At 10,000 revolutions per minute, one millimeter deflection corresponds to 0.00000025 millimeter. There should therefore be no difficulty in detecting pressures as low as 10^{-7} millimeter.

* Abstract of a paper presented at the New Haven meeting of the Physical Society, March 1st, 1913, and published in the *Physical Review.*



Painting Distorted by Oblique Perspective.



Top View of the Aero Camera.

Geographical Charts Prepared by Aerial Photography

By G. Kammerer

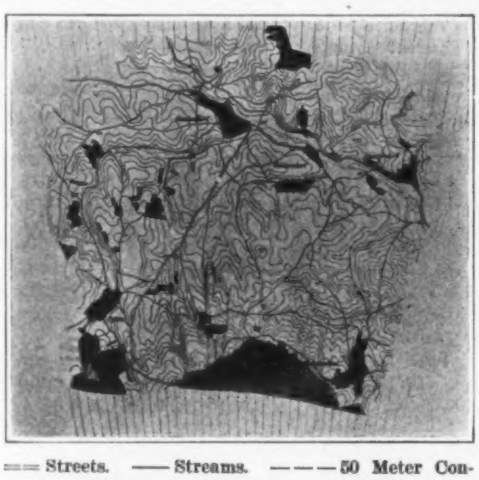
The Same Painting Corrected for Distortion.

At a time when aerial navigation was still in its infancy, an Austrian scientist, Th. Scheimpflug of Vienna, conceived a method for transforming aerial photographs of the earth's surface into geographical or topographical maps.

Everybody who has traveled in the air is struck by the resemblance between the bird's eye view of the earth he gets from his lofty position and a good map, especially as far as roads, rivers, lakes, settlements, etc., are concerned. A bird's eye view vertically downward is in itself a correct map, but only in *level* country; *elevated* parts appear thrown the farther outside their real orthogonal projection as given in a map, the higher they are, and the farther away from a plumb line through the position from which they are observed or photographed. Old time maps represent mountains, hills, even castles, churches and houses, in a similar projection.

While the horizontal direction of every point with regard to this plumb line is strictly the same as on a map, independently of differences in height, the heights themselves can only be determined if at least two views taken from distant positions in the air are available for comparison with each other. Observed under a stereoscope, two such views melt into one, which presents the appearance of a small scale model of the ground with all its plastic features, so that a trained observer can trace with his eyes imaginary lines connecting points of equal height on this model, just as a tourist can follow a level contour line all along a slope.

With a special apparatus this phantom model can even be actually gaged as if it were a solid body; the discrepancies between the two stereoscopic views which create the plastic effect can be accurately measured,



== Streets. —— Streams. — — — 50 Meter Contour Lines. ▬ Forests. ——— 10 Meter Contour Lines.

Orthogonal Map Prepared from Aero Camera Views.

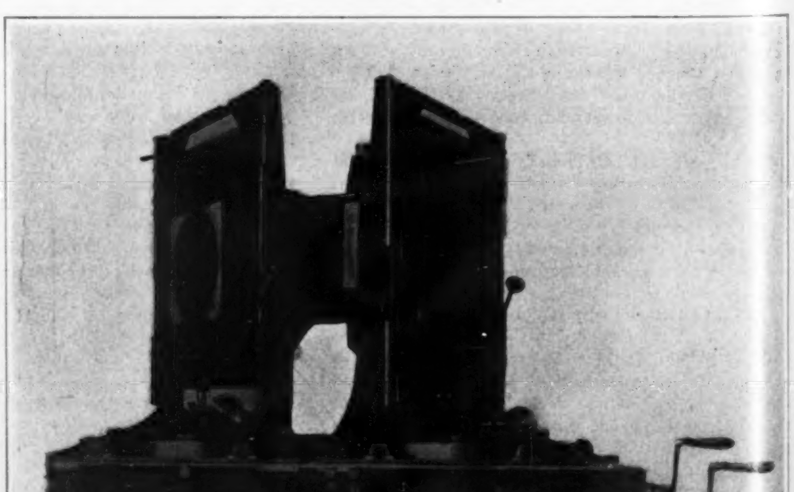
and automatically utilized for the construction of a complete map of the country photographed, with contour lines at prescribed heights or with indications of the heights of any points chosen.

If an ordinary camera is used, the angle of vision is naturally limited by the capacity of its objective. In aerial phototopography, where the position changes continually and where the height above the ground should be as great as possible, to take in a large tract of land, the objective must afford plenty of light; but, since a large aperture which secures that light is incompatible with a very large angle of vision, the Austrian inventor constructed an aero-camera consisting of a central camera which at the moment of exposure points vertically downward, and a ring of inclined cameras fixed around the central one in such a way as to take oblique photographs inclined in all directions toward the horizon, slightly overlapping one another and the central photo. (See "Traveling in the Air," by Col. J. E. Capper, in the *Royal Engineers' Journal*, Vol. XII, No. 3.)

This arrangement increases the angle of vision to such an extent that it covers a circular area the diameter of which is about equal to five times the height of the camera above the ground, that is, about 2 square miles from a height of 1,500 feet, 8 square miles from 3,000 feet, 32 square miles from 6,000 feet, 128 square miles from 9,000 feet.

A "Photoperspectograph," an instrument based on the optical principles of oblique transformation discov-

The Eight-view Aero Camera Ready for an Exposure.



The Photoperspectograph, Which Corrects Photographs for Distortion.

The Sectional Maps of Next View Reconstructed Into a Single View by the Perspectograph.

ered by Scheimpflug, allows the views of the inclined cameras to be photograpically transformed into the plane and scale of the central horizontal view, and to be joined, also photographically, by another special apparatus.

To avoid superfluous, but to insure sufficient overlapping for the triangulation and for the determination of the relief of the ground photographed, from their stereoscopic properties, as described above, the successive views should be taken at distances approximately equal to the average height from which they are obtained, i. e., if the views are taken as quickly after one another as the changing of the plates allows it, a speed of about 12½ miles per hour can be utilized at a height of 3,000 feet, or 25 miles per hour can be utilized at a height of 6,000 feet; and an area surveyed 32 square miles per hour at 3,000 feet or 128 square miles at 6,000 feet.

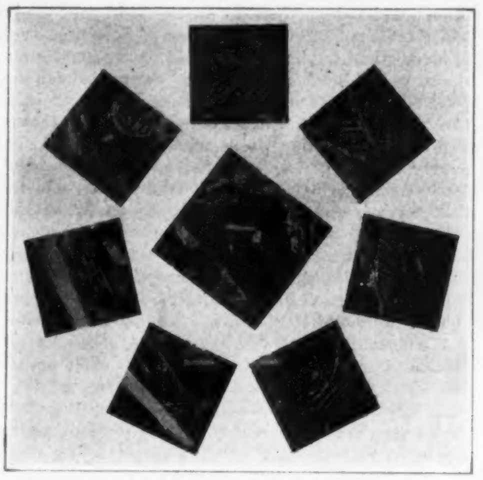
For a survey of German South Africa by his method of aerial phototopography, Th. Scheimpflug worked out the following figures:

Two dirigibles of..........	3,800	7,900 yds.
Average heights	3,000	6,000 ft.
Working hours per day.....	5	10
Total cost	$10,000,000	$3,200,000
To a scale of	1:10,000	1:20,000
Cost per square mile	$18.75	$6.25
Time required for the survey	13 yrs.	3½ yrs.

The figures for a survey to a scale of 1:25,000 by *current* methods are estimated at 50 to 60 million dollars cost, and 150 to 170 years' time, if 20 triangulators and 100 topographers are at work simultaneously.

The cost of an aerial survey can be considerably reduced and the speed still further increased if roll films are used instead of glass plates.

Photographs on films cannot claim the same reliability for very exact measurements as photographs on glass plates, but with certain precautions they still yield wonderful results, so that they may be used for ordinary requirements and most advantageously for all purposes where weight, bulk and fragility would be serious hindrances. In view of the marvelous development of aircraft and its spreading requirements, Th. Scheimpflug's technical successors now pay particular attention to the construction of partly or entirely automatic aero-cameras of every description.



Eight Separate Sectional Views Taken Simultaneously by the Aero Camera.

Problems in Wireless Telegraphy*

The Present Status of the Art, and Outstanding Difficulties

By Prof. J. A. Fleming

THE essential features of the apparatus now used in wireless telegraphy may be described with the aid of diagrams. Figs. 1 and 2. The former represents the plant at a transmitting station.

This consists of three elements: A source giving a high electromotive force, such as the alternator shown at D; a condenser, in which the generator stores an electric charge, to be suddenly released by a discharge at the spark-gap shown; and an open or closed radiative circuit coupled to the condenser circuit, and terminating in an antenna as indicated. Matters should be adjusted so that the spark-gap is discharged solely by energy derived from the condensers. The sparks should follow each other with great regularity at the rate of 400 to 500 per second, and should be dead beat. The receiver also consists of three elements, as shown in Fig. 3. There is an antenna to pick up the radiation, coupled to a condenser circuit, having variable capacity and inductance, and including some form of oscillation detector. At the radiating-station it is necessary that the antenna should have a certain height and also free or insulated ends, but this is not necessary at the receiving station, where a wire laid along the ground serves if it is half the wave-length and properly oriented. The coherer is not now much used as an oscillation detector, as it picks up vagrant waves as well as the signals proper. Telephone receivers are employed instead, and with them some form of rectifier is necessary, such as Fleming's "oscillation valve," which has been largely used by the Marconi Company. This consists of a plate terminal suspended above a hot lamp filament which is connected to the other terminal of the circuit. Negative electricity can pass from the hot filament to the plate, but not *vice versa*, so that the device serves as a rectifier. Carborundum is also used as a rectifier, having a similar property. Almost any metallic sulphide will also serve if in contact with a plumbago point forming the other terminal.

One of the outstanding problems of wireless telegraphy lies in the difficulty of explaining how it is that the signals can be sent over so large a fraction of the circumference of the globe. Thus, communication has been established between Clifden and the Argentine, which is more than a quadrant. If this is the result of a bending round of the waves by diffraction, then it is equivalent to bending ordinary light to the same extent round a globe ¼ inch in diameter. Dr. J. Nicolson, after considering the previous work of Macdonald and Poinairé, has arrived at the conclusion that diffraction can not explain the effects observed in wireless telegraphy without the assistance of reflection from an ionized layer in the upper atmosphere or by some other cause.

Prof. A. Sommerfeld, of Munich, has, however, advanced another explanation, based upon the supposition that the problem is essentially the same as if a Hertzian oscillator were actuated near the boundary of an infinite plane surface, the condition being that the dielectric constant on the one side of this surface differed from what it was on the other. He showed that in these conditions two sets of waves were generated, viz., the waves in space above and below the boundary, which were those usually considered, and a new set of waves spreading along and confined to the immediate neighborhood of the surface. The suggestion advanced was that long-distance radiotelegraphy was effected by these surface waves, and not by the ordinary Hertzian waves in space. The suggestion of such surface waves is not new, and Prof. Baily pointed out in 1903 that the energy of such surface waves would decrease only inversely as the distance from the oscillator, while that of the space waves fell off inversely as the square of this distance. Sommerfeld's investigation was, however, the first strict mathematical proof of the possibility of such surface waves, and if his investigation were valid it would be unnecessary to look further for an explanation of such an achievement as the detection of wireless signals one quarter way round the globe. Further, if Sommerfeld is right, diffraction has nothing to do with the matter. It might be added that in the case of earthquakes the existence of surface waves, in addition to waves passing through the mass of the earth, has long been known.

Sommerfeld's numerical results are in accord with experience in indicating that for long-distance work it is necessary to use long waves, those adopted on the trans-Atlantic service being from 2 to 4 miles long. To explain how these surface waves arise, consider Figs. 3 and 4, representing a Hertzian oscillator H in action near the boundary A B. In the first figure the material on both sides of the horizontal boundary is supposed to be the same, and thus the loop of electric force is identical in both. If, however, the material below the line has a greater dielectric constant the speed of propagation here will be less, and the lower loop will hang back. The feet of the two must, however, be connected as indicated, and the sloping connections correspond to Sommerfeld's surface waves. If the earth were a perfect conductor, these surface waves would be confined to the skin, but in the case of the actual earth even sea-water is a sufficiently poor conductor to allow the surface waves to penetrate for a distance, which, though small, is not so small as to altogether extinguish the wave. If Sommerfeld's conclusion are valid, there should be no difficulty in the surface waves going halfway round the earth.

Another unexplained effect is the influence of daylight in diminishing the distance over which communication can be established. This effect had never been anticipated, while the troubles expected on starting up the pioneer installation has, as usual in such cases, not been realized. In looking out over the Atlantic with Mr. Marconi in those early days we reasoned that America was not in front of us, but rather down below us, and we

* Paper read before the Dundee Meeting of the British Association for the Advancement of Science. Abstract adapted from *Engineering*.

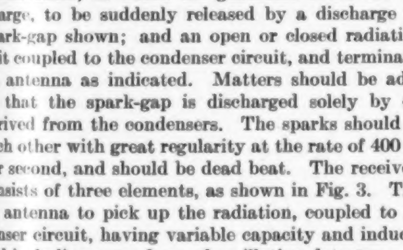


Fig. 1.—Diagram of Transmitting Station.

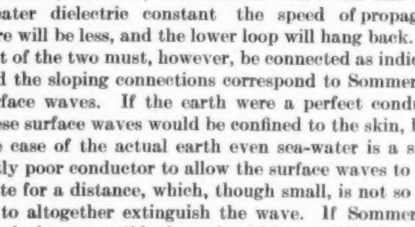


Fig. 2.—Diagram of Receiving Station.

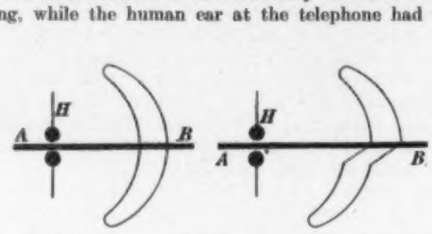
often wondered whether the waves would get round. I had the task of specifying the sizes of dynamos, heights of aerials, and the like, that would be necessary. As to these, we had then nothing whatever to guide us save the good old engineering rule of making a guess at it, and then doubting it. The effect of daylight is well shown in Fig. 5. One question which arises is whether the light merely discharges the antennæ, and thus prevents it from reaching as high a potential as at night. An alternative theory is that the daylight effect due to the ionization of the air between the stations; but neither theory seems to meet all the facts. A peculiar feature is the effect of sunrise and sunset, there being a very pronounced decrease in the strength of the signals received about the time of sunrise at the sending-station, as was well indicated in Fig. 5.

Some interesting observations were made on this point during the recent solar eclipse, the strength of the signals being increased as the shadow passed over the sending-station. The effect may be due to the ions formed in the upper air by the sunlight acting as condensation nuclei for droplets of water, the presence of which would give the upper air a higher dielectric constant. The electric wave would accordingly move more slowly in these upper regions than below, with the result that its front would be tilted up and pass over the receiving-station, exactly as happened with sound. To test this hypothesis the speaker has constructed the wet-mist condenser illustrated in Fig. 6. Here steam is blown through the spaces between concentric tubes, as illustrated. The result reached was that the dielectric constant of mist-laden air was from 1.004 to 1.026 times that of dry air. Whence the ratio of velocities would be as 980 to 1,000, or as 998 to 1,000, depending on which value was taken. This would be sufficient to tilt the wave front enough on a run of a few hundred miles to raise it over the head of a receiving-station. The maximum effect of sunlight on the trans-Atlantic service was found when the shadow boundary is about half way across the Atlantic. The "sunrise nick" shown in Fig. 5 is probably due to the fact that there is then the greatest difference as to ionization between the upper and lower regions of the air. Later in the day convection currents tend to equalize matters, bringing the atmosphere into a more homogeneous condition, and thus obliterating the tilt.

DISCUSSION.

Capt. H. R. Sankey, who opened the discussion, said that Mr. Marconi had intended to be present, but had to proceed to the Continent. This was particularly to be regretted, since many of the questions raised by Dr. Fleming could have been answered by Mr. Marconi. A large proportion of the list of questions formulated by Dr. Fleming had, he went on, relation to theoretical matters, and it was no doubt because theories should be based on experimental results that the formation of a committee of investigation had been brought forward. The Marconi Company had made, and were making, many experiments in long-distance telegraphy, and it was noteworthy that there was a distinct difference in the ease with which communication could be effected N. and S. as compared with E. and W. This no doubt was in part a daylight effect, but the matter was still very obscure; but they hoped shortly to secure full experimental data on the subject. In this connection he might point out that isolated facts were of little service in elucidating a theory, what was necessary being a combination of data.

The plan of preventing interference between wireless systems by tuning them to different wave-lengths was not by any means the only possible method. Many experiments had been made with transmitters tuned to a musical note, which was usually between 400 and 500 vibrations per second. They had, however, gone up to a frequency of 1,000 per second, and this penetrated the "vagrant waves" or "x's" rather better than notes of a lower pitch; but it was, on the other hand, disagreeably high to the operator. What they were now doing was to balance the effect of the sending antennæ on the receiving one by a resonator placed at right angles to the receiving line, and in this way it was found possible to both send and receive from the same station. Moreover, if three sets of signals were being simultaneously received, it was possible by a further development of the method to get rid of two by opposing the one to the other. The third was reduced in amplitude, but could still be distinguished.[1] As to the possibility of replacing the telephone now used for receiving by a recorder, he might add that by means of a photographic relay they had succeeded in working up to a speed of fifty words per minute, and a still better plan had been devised within the past few days which got rid of the main objection to recorders. The trouble with these was that they recorded everything, while the human ear at the telephone had the



Figs. 3, 4.—Diagram to Explain How the Surface Waves Which Travel Around the Earth Arise. The Bend in the Wave Fig. 4 (on right) Corresponds to the Surface Effect.

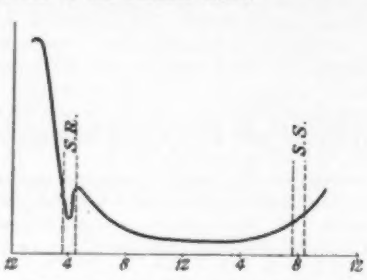


Fig. 5.—Curve Showing Strength of Signals at Different Times of Day ($S.R.$ = Sunrise; $S.S.$ = Sunset). Note the Sudden Drop at Sunrise.

power of distinguishing the true signals from "strays," much as the conductor of a band could at will hear one instrument to the exclusion of the rest. This feature was retained in their new apparatus.

An effective call system had already been worked out,

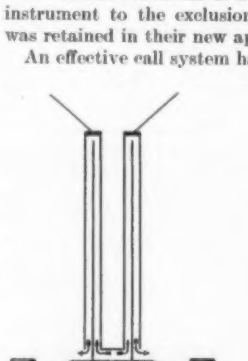


Fig. 6.—Wet-mist condenser, an apparatus designed for determining the effect of moisture upon dielectric constant of air.

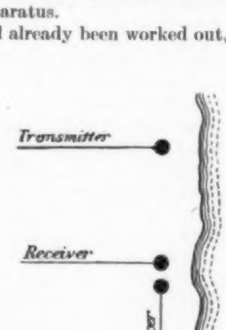


Fig. 7.—Diagrammatic representation of arrangement for receiving and sending from the same station.

though it was not yet applied in practice. As for the Bellini-Tosi goniometer, this was now accurate to within one to three degrees of arc, being thus quite as good as the compass; but a still better device was now in course of development. In their experiments on wireless telephony

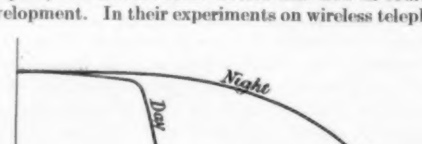


Fig. 8.—Curve Showing the Sudden Dropping Off in the Intensity of Signals at a Distance of About 2,000 kilometers (1,240 Miles) by Day.

at Chelmsford they had succeeded in carrying on effective speech up to a distance of 300 kilometers, and he thought that the limit of distance had not yet been reached. It would, however, be long before wireless telephony could be made commercially practicable. The difficulty lay in the fact that the better it was technically the worse it was commercially, for which purpose it would be necessary to tuue out cross-talk.

With regard to the suggestion that a committee should be appointed by the Association to investigate the subject, Capt. Sankey said that a difficulty would be found in the great differences between transmitting and receiving. A receiving plant was small and easily arranged, but a transmitter required much knowledge and skill. Up to a distance of 1,000 kilometers, however, the difficulties had been overcome, and standard sets of instruments provided. The real difficulties only began to come on when ranges beyond some 2,000 kilometers were to be operated day and night. At the limit mentioned signals dropped off surprisingly during the day (see Fig. 8), and hence, unless the proposed committee had a long-distance transmitting-station, they would get little information of value. In fact, they would require unlimited capital, and the whole world for their laboratory, and to make tests with waves of all wave-lengths. This would bring them into conflict with the terms of the International Wireless Telegraphy Convention. He did not think, therefore, that such a committee could accomplish much, but the necessary data were being now acquired by the experiments of the Marconi Company.

The next speaker was Dr W. H. Eccles, who said that Prof. Fleming had described generally the speaker's hypothesis as to the method by which long ranges were traversed by wireless telegraphy. Prof Fleming had suggested that the speaker had neglected the fact that k, the specific inductive capacity, was not the same for ionized as for unionized air, but this was a misconception. His explanation of the great range of wireless telegraphy was based on the fact that ultra-violet light in passing through air produced two kinds of ions. The one sort, produced where no water vapor was present, was very light, but the other was a globule of water. Hence the condition of the atmosphere in sunshine was indicated diagrammatically in Fig. 9. There was in the first place a lower layer nearly free from ions, and through this the radiation from a transmitter traveled in straight lines. It then entered the middle layer of the atmosphere, which was ionized, under the influence of the sun, with ions of the heavy class. Above this came the layer filled with light ions, and this was permanently ionized night and day, perhaps by the impact of cosmic dust. In traversing the middle layer the radiation was refracted round into a curved path, as indicated in Fig. 10, and bent down toward the earth again. At the same time, however, this refraction was accompanied by a strong absorption, and it was to this absorption that he attributed the weakening of the signals by day. At night the middle layer of ionization disappeared, and the radiation reached the upper permanently ionized layer, which conducted so well that it acted as a reflector, sending the radiation back to earth. He had found that to produce the curvature necessary to fit the earth a degree of ionization was required much smaller than had actually been established by experiment. With short waves day signals were better than at night, since, although the latter were stronger, the day signals were more uniform. The ordinary theory of absorption failed here. On his own theory the middle layer, ionized by the sun, assisted the waves round, but injured the radiation by absorption. At night the upper layer formed a kind of whispering gallery, the electric radiation lighting up the sky when the middle layer was abolished by the setting of the sun. Sunrise and sunset were found to have a great effect on the strength of the signals. On setting the ions in the middle layer began to recombine, giving rise to an electric commotion which would naturally affect the signals. In fact, the conditions were good when the middle layer was absent, fair when it was fully developed, and worst when the conditions were non-uniform.

His principal objection to Sommerfeld's theory of long-distance transmission was that he could manage without it. Mountains, he might add, had a great effect on the signals. Thus a ship at Naples received well from Norddeich, but one at Genoa, in the shadow of the Alps, did not, and similar phenomena had been noted in Australia. The difficulty could be surmounted by using waves of lower frequency, which were more effectively bent by reflection from the upper layer. During the last eclipse he had noticed that signals, strays, and "x's" rose not merely to maximum, but that there were two maxima, with a minimum between. The maxima he considered to be due to the general darkness of the penumbra, and the minimum to the intense shadow of the umbra.

Prof. Howe, who followed, referring to a suggestion in Prof. Fleming's paper that the waves on the surface of a wire traversed by an undulating current were analogous to Sommerfeld's surface waves, remarked that there was, he found, some haziness among electrical engineers as to what Hertzian waves were. This, he thought, might be cleared up if the subject were approached from the usual standpoint of the electrical engineer. Take, for example,

[1] Capt. Sankey and Dr. Pletts have been good enough to explain this arrangement in a little more detail, and it is represented diagrammatically in Fig. 7. Here one of the Marconi "Directive" transmitters is shown side by side with a receiver of a similar character. In transatlantic work the distance between the two may be about 7 miles. In such a case if no balance is employed every signal sent from the transmitter sets the neighboring receiver oscillating, even although the two are tuned to different pitches. The powerful impulse sent out from the transmitter acts, in fact, on the neighborjng transmitter much the same as the blow of a hammer on a bell. To counteract this a third antenna, marked "balancer" in the diagram, is arranged near the receiver, and at right angles to it, as shown. An antenna thus oriented responds to waves coming from the transmitter much more vigorously than the receiver does, which is directed so that it is most sensitive to waves coming from across the Atlantic, and not to waves passing in a perpendicular direction. As a consequence, the balancer responds so vigorously to the impulse from the transmitter, and is so close to the receiver, that it annuls in the latter the waves which would otherwise be set up in it, leaving it free to respond to signals received from over the Atlantic. Since receiver and transmitter are only a few miles apart, it is quite possible to work both simultaneously from the same station.

long-distance circuit, fed by a high-frequency current, then the engineer could work out by his usual vector equations the direction of the current in different parts of the line, and recognized without difficulty that the current might be moving at A (Fig. 10) in the direction shown by the arrows, while at B it might be moving in the opposite direction. Similarly, at B the upper wire was negative, and the lower positive, while at A the reverse was the case. The lines of electric force between the two wires were thus oppositely directed at the two stations, a wave of electric force extending between the two wires. Next, in place of a mere pair of wires, let there be a very large number radiating from the same center and connected at their outer ends with non-inductive resistances. Between the pairs there would be a similar condition of affairs as in the first case, and by making the wires sufficiently numerous they would form a couple of disks—say, 1,000 miles in diameter, and connected up around their outer edges by, say, millions of non-inductive lamps. The next step would be to replace the upper disk by an inverted cone (see Fig. 11), and here again, with a non-inductive load round the edge, the magnetic field and the electrostatic field could be found at all intervening points. Finally, the existence of the upper cone was immaterial as in wireless telegraphy they were only concerned with the lower plate, the electrostatic lines in that case curled round again back to the earth in place of ending in the cone. The case of the earth was, of course, not analogous to that of a copper plate, but the only difference was that the good conductor was insulated instead of being like a bare wire. In that case the energy was partly in the crust and partly in the air. From this point of view, the difficulty was that the waves did not go round even better than they did. On Dr. Eccles' theory, the speaker's inverted cone was replaced by the roof of a whispering gallery.

Prof. S. P. Thompson, the next speaker, wished to draw attention to the fact that no word had been said that morning as to the work of Sir Oliver Lodge, who was the first to show them wireless telegraphy at Oxford in 1894. Sir Oliver Lodge had done so much that he was entitled to much of the credit for what had been accomplished in wireless telegraphy. In fact, if what Lodge had done were removed wireless telegraphy would be impossible.

Lord Rayleigh said that he had always felt that there was a difficulty in explaining long-distance radio-telegraphy on the hypothesis that the earth was a perfect conductor and the air a simple dielectric, and that this was so seemed now to be accepted. Some authorities, however, professed to be unable to see the difficulty. One, for example, had pointed out that the lines of electric force were necessarily perpendicular to a conductor, and thus occupied to the earth exactly the position they should have for the propagation of a wave around it. The same argument, might, however, be applied to sound. Here the direction of motion was necessarily perpendicular to the surface of any solid body encountered, and thus, on the argument stated above, exactly in the direction necessary for the propagation around the obstacle. From this analogy it would be evident that the suggested explanation was inadequate. Prof. Fleming had asked mathematicians to express their views as to the validity of Sommerfeld's work. From the purely mathematical standpoint the speaker had no doubt, from Sommerfeld's standing as a mathematician, that this part of the investigation was quite correct; but on glancing through Prof. Sommerfeld's paper he had found that it would need at least a fortnight's continuous work before he could express an opinion on this point that would be worth anything.. Sommerfeld concluded from his research that the imperfect conductivity of the earth facilitated the transmission of long-distance signals; but at first sight the speaker would have been inclined to the contrary view. First conclusions on such matters were, however, often wrong. On the whole, the speaker was inclined to look more to Dr. Eccles's theory than to Sommerfeld's for an explanation of long-distance transmission. We had these curious anomalies between day and night transmission, and between signalling north and south and east and west, and he thought the phenomena were, therefore, too complicated to be explained by Sommerfeld's surface waves. The complication in question seemed more likely to be due to changes going on in the atmosphere. He had been struck by the fact that the receiver and transmitter were differently arranged. This seemed in conflict with the principle of mechanical reciprocity, which was very generally valid. This principle was, however, based on the linearity of the relationships involved, and might not hold when the disturbances could not be treated as very small. It was here, perhaps, that the reason was to be found for the apparent fact that the best receiver was not also the best transmitter, as would be expected from the principle of reciprocity.

Prof. Kennelly, who spoke next, exhibited some diagrams analogous to Fig. 5 *ante*, showing the effect of sunrise and sunset and the difference in the strength of the signals by night and by day. To explain the effect of sunrise, the speaker said that the conductivity of the atmosphere exposed to sunlight depended upon the pressure. With air at a pressure of 1/100 millimeter the conductivity was comparable to that of a good sulphuric-acid solution. Lines of equal pressure in the upper regions of the atmosphere were also of equal ionization. Hence, with the sun vertical these lines of equal ionization would be level surfaces, and this would still be approximately the case if the sun rays were inclined at any angle substantially below the grazing angle, though the levels would be higher. At sunrise, however, the rays meeting the earth tangentially, the surfaces of equal ionization rose up sharply, so as to meet these rays nearly perpendicularly, and he suggested that this sharp bend upward of the surfaces of equal ionization might be responsible for the sunrise effect.

Prof. Webster welcomed a discussion like the present,

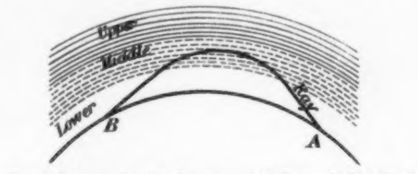
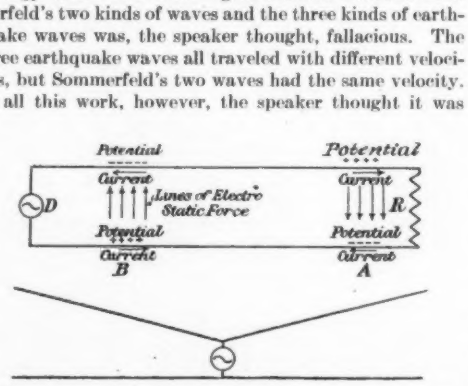


Fig. 9.—Diagrammatic Representation of Ionization of Atmosphere in Sunshine.

because it gave them all an opportunity of talking about the ether, a conception which some parts of the Continent appeared to suppose defunct, and also about ions. He thought a better conception of the difficulty of the problem of long-range radiography would be obtained if they thought of sound, the transmission of which was so dependent on the homogeneity of the atmosphere. A siren might be audible 10 miles away, and inaudible at a distance of a couple of miles, though the eye could see the steam escaping from it. In radio-telegraphy the atmosphere, in view of the local effects of sun and weather, could not be expected to act as if it were homogeneous. To the mathematician, however, the subject was a diffraction phenomenon, but he treated it from the view of diffraction taken in books of optics, which was the kind convenient for mathematical treatment. In the case of sound, however, mathematics had proved quite incapable of determining the maxima and minima of sound round a megaphone, and the problem in radio-telegraphy was more complicated than it was in that of sound. With sound they had to deal with a scalar quantity, but in wireless telegraphy with a vector. It was, however, apparent that if the earth were a bad conductor, they were going to lose a lot. Moreover, the sea was homogeneous and the land not, so better transmission was natural over the former. The fact that daylight affected the transmission showed that there was a lot going on above the surface. The difficulty of the mathematician arose because the variables involved were complex quantities, and not real, as in the case of sound. Prof. Sommerfeld had accordingly been obliged to make certain simplifications, and the question arose as to whether these were legitimate. It was true, of course, that he was a mathematician of the greatest skill. The analogy which Prof. Fleming had drawn between Sommerfeld's two kinds of waves and the three kinds of earthquake waves was, the speaker thought, fallacious. The three earthquake waves all traveled with different velocities, but Sommerfeld's two waves had the same velocity. In all this work, however, the speaker thought it was



Figs. 10, 11.—Prof. Howe's Explanation of the Nature of Electric Waves.

marvelous the way in which Clerk Maxwell's equations were confirmed by experiment. He agreed with Prof. Fleming that co-operation might do a lot to elucidate the question. He thought arrangements might be made for occasional use for short periods of the Tour Eiffel and other stations, and that the Wireless Telegraphic Convention would in this matter be a help, and not a hindrance, as Capt. Sankey had suggested, since they would have power to make other stations keep quiet for the time.

Major Squire, who was next called on, said that the United States War Department had thought it of interest to investigate the possibilities of what he might call wired wireless telegraphy, using frequencies much smaller than those used in wireless telegraphy, and much higher than were used in ordinary telegraphy. The plan was to make their antennæ stretch the whole distance between the sending and the receiving station, and to pick up the signals there by apparatus of the "wireless" type. It was found necessary to have some generator capable of yielding a sustained series of oscillations. This was constructed for them by the General Electric Company, the frequency being 100,000 cycles per second, but the machine could be run to give as little as 20,000 cycles per second. Driving this machine with a storage-battery, oscillation at the above rate could be sustained for hours at a time. The lines used in transmission were of known impedance, but on putting the plant to work it was found that the inductance was increased, and capacity had to be added to establish resonance. Making use of previous experience in wireless work, it was found quite easy to get good results. For a range of 400 miles the energy needed was very small as compared with ordinary radio-telegraphy, the line between Baltimore and New York being operated easily with 40 or 50 volts. The frequency being far beyond the limit of audition, it was possible to telephone simultaneously along the same wire by the ordinary battery system. A Fleming valve was used as a rectifier at the receiving end, and duplex telephony was easily practicable, one set of instruments being operated with these rapid oscillatory currents, and the other by the ordinary battery system. There was no interference whatever, and daylight did not have any prejudicial effect.

Dr. J. Nicolson, the next speaker, said that three independent investigations had arrived at equivalent results when the problem of long-range transmission was considered as one in diffraction, taking the earth as a good conductor. He had carefully studied Sommerfeld's work, a matter of some difficulty, owing to misprints, and concluded that there was no error in the mathematics. Nevertheless, he was disposed to agree with Lord Rayleigh's "first thoughts," to the effect that bad conductivity should not facilitate transmission. There was just one point in Sommerfeld's assumptions which was, perhaps, doubtful. His investigation, strictly speaking, related to an infinite plane surface, and it was assumed that the result found for this would not be materially different for the case of long-distance transmission over the earth. Diffraction difficulties, however, only arose after about 1,000 miles, corresponding to a considerable amount of total curvature, and it might well prove that Sommerfeld's solution would only hold for points within a small range of the transmitter. If the investigation were at fault, he thought that this was where the defect would lie. Short of getting, however, the complete solution for the sphere which only wanted working out, this opinion could not be tested. He was on the whole, however, tempted to believe that the surface waves would be found to correspond to the state of a flat surface only, and to accept Dr Eccles' view of the matter.

Mr. Brown said that in 1899 he had made many experiments in directed wireless telegraphy, the results of which had been published in the *Electrician*. In these he met with many anomalies. At times the transmission would after being difficult suddenly brighten up enormously without apparent reason. He stated that he had now produced a telephonic receiver which was twice as loud as the best Bell instrument yet made. With the latter, the sounds produced by the wireless waves were so faint that an ordinary person failed to hear them at first. He had also now got a relay which would pick up signals otherwise quite inaudible.

Prof. Baily remarked that Prof. Fleming had recalled that the speaker had suggested some years ago that surface waves might be responsible for the long ranges attained in wireless telegraphy, and he believed that, whatever the relative value of Sommerfeld's and Eccles' hypotheses, these waves must actually exist, though as to how far they extended was another matter. He had made a number of experiments to determine the resistance of the earth, which showed that for a depth of several miles this was comparatively high, but even very slow oscillation would not penetrate to a depth of more than 50 to 100 miles. This was so little compared with the diameter of the earth that the latter might for ordinary purposes be taken as a conductor. At a depth of about 60 miles the conductivity increased very rapidly, so that below this limit the earth was a very good conductor.

In reply, Prof. Fleming said that matters in radio-telegraphy had now reached a point at which further accurate data were badly needed, and he maintained accordingly that a radio-telegraphic committee would render most valuable services. Data absolutely indispensable were still conspicuous by their absence.

Prof. Callender, in moving a vote of thanks to Dr. Fleming for initiating so brilliant and so interesting a discussion, felt certain that the meeting would indorse the suggestion that the proposed committee be appointed. An important contribution to the discussion by Dr. A. Sommerfeld, of Munich, was not read owing to the pressure of time. It will be included, however, in the British Association Report, and we hope to deal with it later.

NEW BOOKS, ETC.

Moderne Technik. Die wichtigften Gebiete der Mafchinentechnik und Verkehrstechnik. Allgemeinverftändlich dargeftellf und erläutert durch zerlegbare Modelle. Unter Mitarbeit hervarragender Fachmänner herausgegeben von Ingenieur H. Blücher. Mit 1391 Abbildungen im Text und 15 zerlegbaren Modellen. Leipsic: Bibliographisches Institut, 1912. 2 vols. Price, $10.

One of these volumes consists of fifteen dissectable paper models of highly important modern pieces of mechanism, and the other of a volume of text. The models, of which the first volume is composed, very clearly set forth the construction of a modern waterproof boiler, a double-expansion steam engine, a steam turbine, a four-cycle Koerting gas engine, a Diesel engine, a direct-current motor, an alternating-current motor, a Lanz threshing machine, an Adler automobile, a superheated steam locomotive, the twin-screw steamer "George Washington," a submarine boat, a Parzeval airship, a Rumpler monoplane, and a Hughes printing telegraph. It would be difficult indeed to exaggerate the value of these models for educational purposes or the painstaking manner in which they have been prepared. From the list of the models that we have given, it will be observed that all of them disclose essentially modern inventions. The volume of text is by no means confined to a description of the models. Indeed, it covers the entire field of electrical and purely mechanical devices, and has been prepared with the express purpose of disclosing both the construction and the operation of the more important machines that are used in modern industry. Thus we find hydraulic motors discussed as well as steam engines, internal-combustion engines, electrical generators, motors, transformers, storage batteries, measuring instruments, auxiliary apparatus, power stations, electric lighting systems, electric railways, etc., lifting and conveying mechanism, pumps, compressors, milling machinery, clay-working machinery, wood and metal working machinery, bookbinding machinery, printing presses, agricultural machinery and implements, vehicles (motor cycles and motor vehicles), railway construction and apparatus, aerial navigation, telephonic, telegraphic, and radio-telegraphic apparatus. The book is to be heartily commended to the undergraduates of most of our technical institutions who are able to read German.

Jahrbuch der Naturwissenschaften. 1910-1911. Von Dr. Joseph Plassmann. Freiburg im Breisgau; Herdersche Verlagshandlung, 1911. 458 pp. Price, Mk. 7.50.

Annuals of the kind of which this is representative have a very marked value. There is so much happening in the world of pure and applied science these days, that no one can possibly hope to do more than keep himself informed of the most essential things in the entire field, and perhaps on matters of greater detail in some special field. A book of this kind gives the reader an excellent survey of the most important advances made within the year 1910-1911.

To form an idea of the field covered, we give a list of the main headings of the book: Mechanics, Physical Chemistry, Heat, Light, Electricity and Magnetism, Chemistry, Astronomy, Aeronautics, Meterorology, Anthropology, Mineralogy and Geology, Zoology and Botany, Forestry and Agriculture, Geography and Ethnology, Hygiene and Medicine, Applied Mechanics and Industries, Sundries. The book is a useful work of reference to have on one's desk.

Praktische Chemie. Von Dr. Felix B. Ahrens. Zweite Auflage. Durchgesehen, verbessert und erweitert von Prof. Dr. F. W. Hinrichsen. Mit zwei farbigen, vier schwarzen Tafeln und zalreichen Text-abbildungen. Stuttgart: Ernst Heinrich Moritz, 1912.

The admirable introduction into practical chemistry which the late Prof. Felix B. Ahrens of the University of Breslau wrote some years ago, and which has proved deservedly popular in Germany, has been brought up to date by Prof. Dr. F. Willy Hinrichsen. The inorganic portion of the book remains substantially as it was, with the exception that it has been brought up to date wherever necessary. This, Prof. Hinrichsen assures us, was a matter of literary and scientific piety; for it seemed a pity to modify more than was absolutely necessary Prof. Ahren's admirably clear and happily framed expositions. Although the same principles govern the revision of the organic portion, Prof. Hinrichsen's hand is here more noticeable. The chapter on carbohydrates, proteids, and albumen has been completely rewritten. In common with most modern chemists, Prof. Hinrichsen insists upon a more sparing use of protein and albuminous substances in food. The general manner of treatment, as well as the scope of the little book, may be gleaned from the chapter headings: Structure of the Universe; Twixt Heaven and Earth; the Language of Chemistry; Hydrogen and Oxygen; Chlorine; Sulphur and Sulphuric Acid; the Nitrogen Group; Metals; Radium and Radioactivity; the Secrets of Organic Nature and the Work of the Chemist in Their Solution; Carbon; Hydrocarbons; Coal; the Treatment of Coal Tar; Sugar, Starch, and Cellulose; The Alcohols; Fats; the Significance of Carbonhydrates and Albuminoids in Nutrition; Glycerine and Explosives.

Practical Aeronautics. By Charles B. Hayward: With introduction by Orville Wright. Chicago: American School of Correspondence.

Mr. Hayward's work, entitled "Practical Aeronautics," is a weighty volume of over 750 pages, graced with an introduction by Orville Wright and resplendent with illustrations and diagrams; but one is apt to be struck, at first, with its familiarity, and to recognize in the volume many old friends.

On close examination, this proves to be the case; and while Mr. Hayward has been thoughtful enough once or twice to give recognition to his sources, several well-known books and articles pertaining to aviation are taken *verbatim*, with absolutely no acknowledgment of indebtedness. We cannot undertake to point out in detail all the particular instances of piracy, but many editors of aeronautical papers will find in "Practical Aeronautics" much of their most cherished material.

Despite the fact, however, that Mr. Hayward has chosen his subject matter with rare discrimination, he has made a fatal mistake in arranging it so poorly, and the inevitable result of lack of care has caused him to repeat and contradict himself many times.

Not the least obvious appropriation of other's thoughts and work is the wholesale copying from Grover Cleveland Loening's recent work, "Monoplanes and Biplanes," published by Munn & Co. With scarcely no alteration or rearrangement, almost 100 pages of Mr. Hayward's imposing volume are "inspired" by Mr. Loening's book, many of the diagrams being faithfully reproduced, and the wording coinciding with unmistakable accuracy; no credit is given to the latter, and no mention made of the publishers.

In sections of Aerodynamics, Mr. Hayward has changed the lettering of formulæ, but has preserved much of the arrangement and many computations, giving without credit to him the results of Mr. Loening's investigation of the constant *K*.

A like similarity is true of the descriptions of many of the machines, the same subdivisions and terms being used as are found in "Monoplanes and Biplanes."

To cite a particular instance, the section on rudders and keels, pages 265, 266 and 267 of "Practical Aeronautics," is word for word the same as is contained in "Monoplanes and Biplanes," pages 251 to 255. It would occupy too much time to sum up the many sections or chapters that have been garbled in as striking a manner, but rarely has there been so obvious a series of plagiarisms.

Were but half of the contents of the book properly arranged, and a logical sequence given to the matter it contains, there would be some value to the volume; but its chaotic make-up can hardly be recommended as illuminating on this highly important subject.

Hazell's Annual for 1913.

Next to the extraordinary variety and extent of its information, the most notable feature of Hazell's Annual for 1913 is the judicial impartiality with which it deals with debatable subjects. The Annual would fail to fulfill its functions if it did not give adequate space to the political and religious questions of the day; yet topics of such keen controversy as Home Rule, Electoral Reform, Welsh Disestablishment, the Taxation of Land Values, and the Report of the Divorce Commission are discussed in a manner acceptable alike to Unionists and Liberals, Anglicans and Nonconformists. It should be added that the maps illustrating the story of the Balkan War, the Panama Canal, the Imperial Wireless Scheme, and the proposed railway to India are admirably printed, and that the clearness of the index, with its 7,000 references, greatly adds to the utility of the volume.

Abstract-Bulletin of the Physical Laboratory of the National Electric Lamp Association. Cleveland, O. Edward P. Hyde, director. Cleveland, 1913.

During the four years of its existence the physical laboratory of the National Electric Lamp Association has performed some notable work, the results of which are presented in this Bulletin. The laboratory is probably unique. Although established by a commercial enterprise, it has no commercial object in view. Its researches are conducted in pure science on exactly the same principles that control similar work in government and university laboratories. For this reason alone, the investigations which have been made under Dr. Hyde's direction deserve more than ordinary attention. In the Bulletin before us, papers are published by Drs. Hyde, Ives, Cobb, Luckiesh—all names which, since the establishment of the laboratory, have become familiar to readers of the technical press in which the papers have been republished. The authors in these papers discuss the problems of light and illumination from every angle. The physicist, the psychologist, the physiologist, the chemist, all are represented.

Geographie des Atlantischen Ozeans. Von Prof. Dr. Gerhard Schott, Abteilungsvorstand bei der Deutschen Seewarte in Hamburg. Mit 1 Titelbild, 28 Tafeln und 90 Textfiguren. Hamburg: Verlag von C. Boysen, 1912. 4to.; xii, 330 pp. Price, 23 marks.

The publication of this, the first great comprehensive geography of an ocean, is a real event, a forerunner of which was Dr. Schott's splendid contribution to the report of the "Valdivia" expedition, published in 1902. The author, a veteran oceanographer, is in charge of the Division of Oceanography and Maritime Meteorology at the Deutsche Seewarte—an institution which probably deserves to be regarded as the intellectual center of the maritime world.

First of all, the book is sumptuously made. It is a delight to the eye. In paper and type, in the exquisitely colored seascape (after a painting by Prof. Schnars-Alquist) which forms the frontispiece, and the charts, the numerous colors of which all "register" to a hair's breadth, it exemplifies the fact that German publishers of scientific books are not less conscientious about details than are the writers of the same books.

Chapter 1 is a history of discovery and exploration over the Atlantic, from the days when the Pillars of Hercules were the end of the known world down to the latest polar expeditions. The charts in this section include many quaint specimens of early cartography. Chapter 2 deals with the name, the boundaries, the divisions, and the size of the Atlantic. Chapter 3 is geological. Chapter 4 discusses the results of soundings and the character of the ocean bed. Chapter 5 deals with the physical phenomena of the water—color, salinity, temperature, currents, etc. Chapter 6 devotes 60 pages to the climate—or rather climates—of the Atlantic, with charts of air-temperature, barometric pressure, winds, cloudiness, fog and rainfall. Chapter 7 treats of the biology of the Atlantic, including the fisheries. The final Chapter 8 deals with the traffic of the Atlantic; viz., steamship and sailing routes, cable lines, radio-telegraphic stations, and kindred matters.

It is hardly necessary to say that Dr. Schott's book has no parallel in the English language. Findlay's directories for the North and the South Atlantic are the nearest approach to it, but their point of view is quite different. In German, the official "Segelhandbuch fur den Atlantischen Ozean," published by the Seewarte, will remain an indispensable book in nautical libraries, notwithstanding the publication of Schott's work, which overlaps it to a great extent.

Handbuch für Heer und Flotte. Enzyklopädie der Kriegswissenschaften und verwandter Gebiete. Herausgegeben von Georg von Alten, Generalleutnant z. D. Fortgeführt von Hans von Albert, Hauptmann a. D. Leipsic: Deutsches Verlagshaus Bong & Co., 1912.

These three installments (51, 52, and 53) of the "Handbuch fuer Heer und Flotte" are particularly timely; for there is an admirable article on Greece, in which we find the latest information on the Greek army and navy, the topography and people of Greece, and other information which any one who has followed the Balkan war will read with instruction and interes Other articles which deserve to be mentioned are those on *Geschoss, Geschosswirkung, Geschuetz, Geschuetze des Altertums*, in other words, a history of projectiles and ordnance. Sanitation is admirably discussed under the heading "Gesundheitspflege." Military tactics, military formations, grenades, grenade fuses, etc., are discussed in still other articles. Among the battles which are taken up are those of Gibraltar, Gitchin, Graudend, and Gravelotte. The biography of Gneisenau, written by General Count von Schlieffen, is a model in its way. There are many maps, diagrams, and illustrations that heighten the value of the text. Since the death of Lieut.-General Georg von Alten, this admirable encyclopedia is edited by Captain Hans von Albert.

Electricity. Its History and Development. By William A. Durgin. Chicago: A. C. McClurg & Co., 1912. 12mo.; 176 pp.; illustrated. Price, $1.

Heaton's Annual. The Commercial Handbook of Canada and Boards of Trade Register. Toronto: Heaton's Agency, 1912. 12mo.; 562 pp.; Price, $1; postage, 12 cents.

The Bungalow Boys. By Dexter J. Forrester. New York: Hurst & Co., 1911. 12mo.; 303 pp.; illustrated. Price, 50 cents.

Business and Kingdom Come. By Frank Crane. Chicago: Forbes & Co., 1912. 12mo.; 100 pp. Price, 75 cents.

The Beginner's Guide to the Microscope. By Charles E. Heath, F.R.M.S., London: Percival Marshall & Co. 12mo.; 119 pp.; illustrated. Price, 50 cents.

Mission Furniture. How to Make It. Part Three. Chicago: Popular Mechanics Company, 1912. 12mo.; 120 pp.; illustrated. Price, 50 cents.

Brewing. By A. Chaston Chapman. New York: G. P. Putnam's Sons, 1912. 16mo.; 130 pp.; illustrated. Price, 40 cents net.

Practical Rifle Shooting. By Walter Winans. New York: G. P. Putnam's Sons. 16mo.; 98 pp. Price, 50 cents.

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